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Troposcatter Communications for Intercontinental TV Transmission

By EDWIN DYKE

The strides being made toward realizing the dream of international television are discussed. The suitability of troposcatter for achieving this goal is the central theme, with reference to feasible path lengths and reliability. Recent developments toward obtaining satisfactory performance are presented, including such factors as diversity, single-sideband, variable powers and bandwidths, and masers. Current troposcatter installation techniques are illustrated.

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1. Introduction

Intercontinental television by troposcatter propagation has been widely discussed.[1] We have therefore confined ourselves to recent technical advances. Noteworthy in the earlier literature is the scatter-propagation issue of the *Proceedings of the IRE* (October 1955), and we refer to papers in it as indicated.

Section 2 presents a brief introduction to troposcatter phenomena in the light of our recently increased understanding of them. Section 3 discusses inventions to increase carrier-to-noise ratio, as well as other component improvements, and describes some experience in installing available equipment. Section 4 (with Appendixes I and II) outlines some technical problems on the NARCOM system. The appendixes present a technique for calculating the optimum number of hops and a sample system design.

Presented on October 23, 1958, at the Society's Convention in Detroit, by Edwin Dyke, Page Communications Engineers, Inc., 710 Fourteenth St., N.W., Washington 5, D.C.
(This paper was first received on July 1, 1959, and in final form on November 20, 1959.)

No attempt has been made herein to suggest a design for a complete system (see literature for one-hop plans).[2,3,4] Instead, emphasis has been given to the few most significant recent data on which reliance can be placed for improved final results.

We must emphasize to readers, and particularly to those who are not radio specialists, that intercontinental television requires a significant extrapolation of present limited experience, which is based on many factors that are as yet imperfectly known, as noted in specific cases below. Also to be appraised is the acceptability of various probabilities of reduced perfection and reliability. All these speculative factors have been weighted with our present best judgment.

2. Troposcatter Phenomena

2.1. Basic Operation. The propagation phenomena have been discussed core siderably in recent literature. Notable ana a small book by Kamen and Doundoulakis,[5] a summary by Staras,[6] and the latest JTAC report.[51]

The three known types of scatter are tropospheric, ionospheric and stratospheric. Figure 1 shows the basic conventional geometry of these types on an equivalent 5000-mile earth radius. They vary according to the height of the scattering medium; for troposcatter this height is indirectly measurable by the angle θ, or by the path length along the earth's surface.

The highest (ionospheric) scattering is now useful only for narrow bands, voice or telegraph, 25 to 60 mc, range 600 to 1400 miles. The lowest or troposcatter (two dozen or so miles high) is suitable for TV, a few hundred to several thousand megacycles with ranges, say, of 60 to nearly 1000 miles for voice but only a few hundred miles for TV.

The phenomena are only imperfectly known. See Booker and Gordon[7] and Crain[8] on stratospheric scattering in radio communication and refraction measurements, respectively.

Total path loss is considered to consist of two components, illustrated in Fig. 2. One is free-space inverse-square power loss (6 db per doubling of distance). The other is scatter-loss due to the weakness of scattering that occurs in the shaded part of the sketch. A sharp pulse is stretched into the time difference between the two heavy narrow paths.

The loss is affected by any obstructions, such as that illustrated in the sketch. Thus a site on a high altitude is preferred; otherwise the beam has to be elevated above the obstacle, with larger θ, and with path loss at least 10 db more per degree increase.[2,9] Required antenna ground clearance is about 20 or 30 wavelengths for nearly maximum efficiency.

Propagation between antennas may be in modes other than scatter as, for example, aircraft reflections, knife-edge diffraction over a sharp mountain ridge (rare),[10] or super-refraction (or ducting) of the atmosphere (also somewhat rare).[11] These modes interfere as echoes to the scatter signals and sometimes are dominant.

2.2. Techniques for Basic Troposcatter Calculations. The radio scientists have made mathematical models for almost

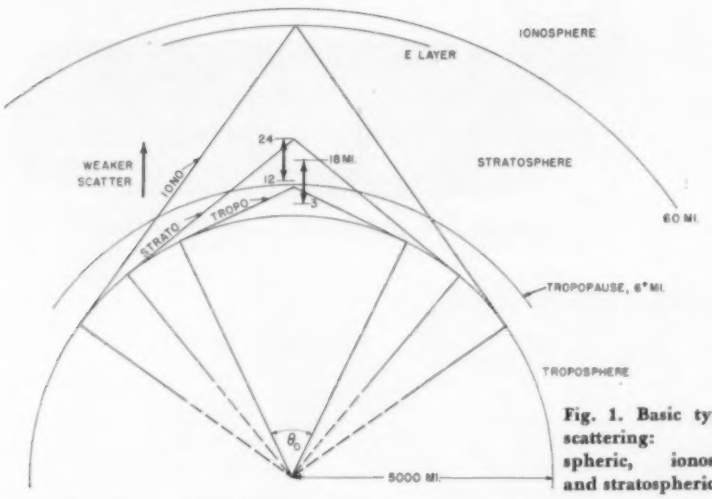

Fig. 1. Basic types of scattering: tropospheric, ionospheric and stratospheric.

everything that one needs to know about troposcatter. These are the basis for all present scatter calculations. The models, however, are not necessarily accurate and, in fact, a few (notably bandwidth and antenna-medium coupling loss) presently are not in good agreement. Thus, when we refer to our knowledge of the subject, the reference applies largely to the collection of models.

All the information derived from the models is statistical, i.e., any single-number conclusion is only a mean value. If more complete information is needed, it appears as a probability distribution graph (numerical information vs. per cent of the time during which it applies.[12,13] Thus, the predicted values of troposcatter transmission loss are simply the values "most likely to occur." An analysis[14] of today's prediction methods has compared some theoretical calculations with the measured path loss and shows the "service probability" (probability of the path loss prediction being successful) versus the expected "time availability" (per cent of the year) of the various "grades of service" (hourly median carrier-to-noise ratio). In typical cases, the median signal availability (50% of the year) had a service probability of about 0.995 — almost a certainty; a weak signal calculated to have 99% time availability had a service probability of only 0.5.

2.3. Climate. The most accurate calculation takes into account the different climates throughout the world during different seasons. The strongest scattering occurs in moist tropical areas; the weakest, in the northern hemisphere, occurs during winter afternoons when the scattering is more free from other propagational modes. Snow and rain weaken the signals slightly; the effect of fog is uncertain.[15] Transmission over water appears to be slightly stronger than transmission over land.[16] Higher temperatures help.

2.4. Slow Fades. Slow fades follow the Gaussian model quite closely.[2,15,17] Figure 3, after Rice,[13] shows the statistics of fading for all hours of the year, and one

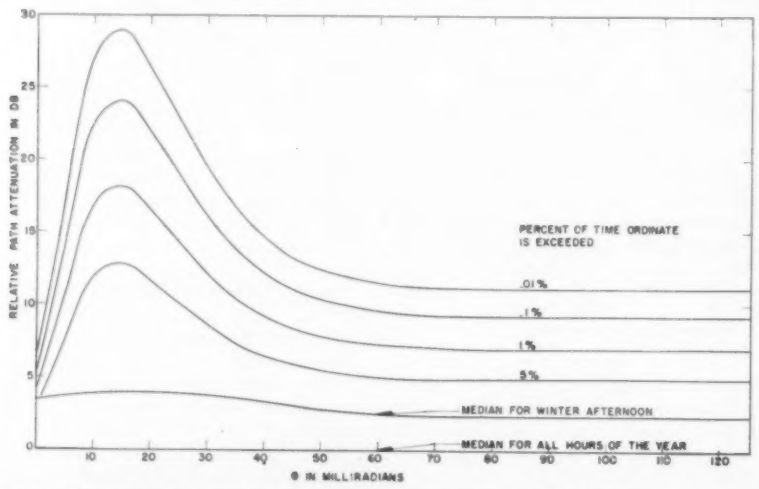

Fig. 3. Tropospheric-scatter long-term fading; 100–4000 mc (after Rice[13]).

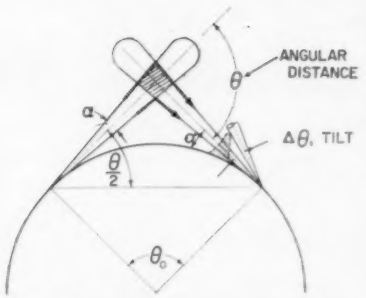

Fig. 2. Basic parameters for troposcatter beams (not to scale).

median curve representing winter afternoons only. At the abscissa, each milliradian is equivalent to about 5 miles of distance between radio horizons for smooth earth; thus, those exceeding about 300 miles suffer an essentially fixed depth of fade which, for example, would not be worse than 10 db for 99.9% of the time.

2.5. Fast Fades. The scattering media shift constantly, producing alternate fading and enhancement at a rate of about 2 cycles/sec, varying with distance and antenna size through a range of about 0.1 to 10.0 fades per second. This fading follows a Rayleigh distribution,[18] namely, $Y = 100\,e^{-0.0931P}$, where Y is the probability in per cent, and P is the power relative to median power. Thus probable received signal 90% of the time is not weaker than 8 db below the median and 18 and 28 db 99% and 99.9% of the time, respectively. The hourly median or even that by the minute[19] varies slowly throughout the day and year.

2.6. Total Fading. Slow and fast fades affect system performance simultaneously; an accurate means for accounting this is quite complex.[4] For TV purposes, it may be suitable to account in the fade margin only the slow fade and to account the fast fades in the required value of signal-to-noise ratio. Though this kind of fast-fade accounting has been tried for one hop of TV,[20,21] it still appears to be unresolved as a cumulative effect through several repeater stations and with diversity.

2.7. Effect of Carrier Frequency. As yet no reliable model exists for determining the effect of carrier frequency on scattering efficiency. For shorter hops, the per unit transmission may be proportional to the wavelength; but, again, the effect can be described[22] only by statistical methods.

2.8. Antenna-to-Medium Loss. When the carrier frequency, antenna size and path length all are relatively large, the antenna functions with an efficiency that is substantially less than the free-space values.[22] Possibly the antenna should be elliptical in shape instead of circular, to help reduce this loss.[7] Figure 4 from Staras[22] shows two models of the median

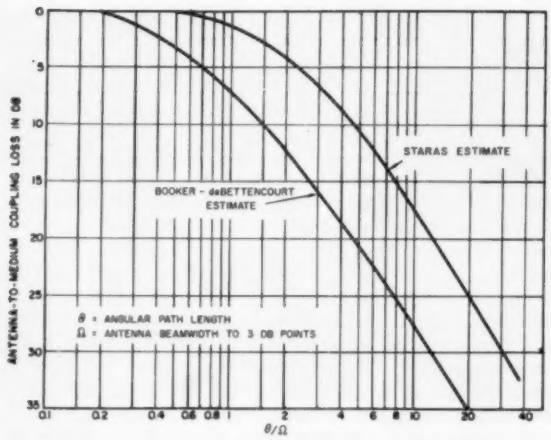
ANTENNA-TO-MEDIUM COUPLING LOSS IN DB
STARAS ESTIMATE
BOOKER - deBETTENCOURT ESTIMATE
θ = ANGULAR PATH LENGTH
Ω = ANTENNA BEAMWIDTH TO 3 DB POINTS
θ/Ω

Fig. 4. A comparison of two estimates for coupling loss assuming identical paraboloidal antennas at each end.[23]

value of this loss for ordinary paraboloidal antennas. An accurate and empirical distribution of this loss has not as yet appeared.

2.9. Television Bandwidth. That monochrome and color TV bandwidths are feasible for at least the short hops, say 200 miles or so[9,24,25] has already been established. Bandwidth has been the subject of much technical literature.[2,6,7,9,26,27] The exact numerical values are in dispute, but certain facts appear to be clear, namely, that (a) the bandwidth is improved for high-gain antennas and falls off with the cube of the distance; and (b) the same mechanism that causes fast fades also reduces the bandwidth, so that fading may be considered in both bandwidth and signal amplitudes. Other reasons for desiring a narrow bandwidth are that the signal-to-noise ratio would be better, and the radio spectrum utilization would be more efficient. Consequently, much effort is being directed toward means for reducing the required bandwidth for both monochrome and color. Such systems[28,29] have already worked with a bandwidth reduction of about 3:1, and much greater improvement is expected. Pulse-stretching increases with path length.

The available bandwidth is not fully utilized in today's TV systems, so that insertion of a 2-mc-wide filter usually makes little difference in a nominal 4.5-mc-wide channel. The bandwidth necessary to support the visually perceivable change may be as low as 50 cycles/sec.[30] Thus, the art of bandwidth reduction has scarcely started, and its end point would enormously improve the TV tropo link. Roughly speaking, each 16:1 reduction of bandwidth allows another 100 miles of scattering loss in each hop, with all other parameters fixed.[2]

3. Inventions to Improve Carrier-to-Noise Ratio

3.1. Reduction of Receiver Input Noise. The receiving system noise, which limits its sensitivity, may be expressed[31] as

$$T_s = T_A + T_R$$

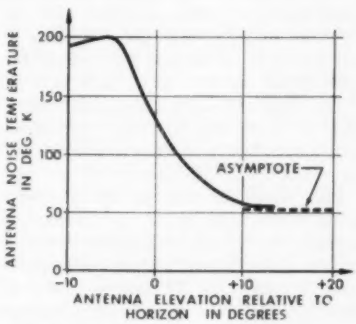

Fig. 5. Sky noise in a particular installation.[34B]

or

$$F_s = \frac{T_A}{290} + \frac{T_R}{290}$$

where T = noise temperature (apparent degrees Kelvin),[32]
F = noise factor (power rating not db),[33]
s = total noise seen by system,
A = total noise seen by antenna, and
R = total noise in receiver, referred to its input terminal.

These terms are related by

$$F_R = 1 + \frac{T_R}{290}$$

$$F_A = \frac{T_A}{290}$$

$$F_S = \frac{T_S}{290}$$

Antenna noise temperature[32] is that picked up from the sky, earth and star noise sources, such as shown in Fig. 5 (from Ref. 34B) for a particular frequency, terrain, antenna, location, orientation and time. These expressions can be corrected for the power loss ratio L (reciprocal of per unit transmission) of the transmission lines by replacing F_R with LF_R or replacing T_R with LT_R (but not both at once). Handling these equations accurately in practice is quite complex.

By way of introducing two new devices, the maser (see Section 3.2) and the parametric amplifier (see 3.3), Table I, showing both noise temperature and noise figure, demonstrates improvement in receiver and system noise over that obtained with a typical diode. (The negative noise figure merely means less noise than the arbitrary reference of 290K inherent in the definition of noise figures).[33] Assumed is an approximate frequency of 1000 mc, no transmission line loss, and an antenna noise temperature of 130 K.

Table I. Performance Comparison of Diode, Parametric Amplifier and Maser.

Typical Input Stage	Diode	Parametric	Maser
Receiver noise factor, F_R.....	6	1.25	1.007
Receiver noise temp., T_R, °K..	1450	72.5	2.03
System noise temp., T_s, °K..	1580	202.5	132.
System noise factor, F_s.....	5.4	0.7	0.455
or in db, F_s....	7.4	−1.55	−3.4

3.2. Maser. The maser (Microwave Amplification by Stimulated Emission Radiation) uses a tiny bit of mineral (ruby or others) mounted in a microwave holder in a manner producing amplification with practically no added noise.[35] To preserve this performance, signal loss must be minimized by mounting the maser very close to the receiving antenna. The maser assembly requires refrigeration to nearly absolute zero, a magnetic field and an injection of radio-frequency energy (pumping frequency). The sensitivity of any receiving system is a matter of input circuit noise. The noise generated by the maser is so low that the system noise is defined almost entirely by the sky (and terrain) noise picked up by the antenna. Of course, at low enough carrier frequencies where the noise figure available from standard input circuitry is sufficiently low (or sky noise sufficiently high), the maser serves no purpose.

3.3. Parametric Amplifier. The parametric amplifier has also been called the mavar (Microwave Amplification by Variable Reactance). Various forms exist, such as semiconductors, electron tubes and ferrite devices. Its operation is based on varying the reactance of a circuit at a microwave rate without generating much extraneous noise.[36,37] The parametric amplifier works properly at room temperature; in some cases its performance could be improved by refrigeration, but cooling to near absolute zero is unnecessary. Also, in some designs a magnetic field is not needed. The parametric amplifier is not at present a fully matured component which is available and stable at all frequencies. However, it is rapidly approaching such a stage, and Fig. 6 (from Heffner and Kotzebue[38A]) is indicative of the simplicity that is basically possible in the diode version. Figure

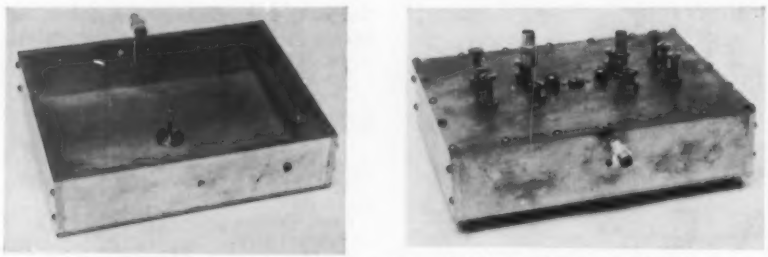

Fig. 6. Experimental mavar (a) with cover removed; (b) complete assembly.[38,4]

6(a), which shows the unit opened, is complete except for the coupling loops and tuning screws shown assembled in Fig. 6(b). Two of the coupling loops are for signal input and output; the third is for the pumping oscillator from which energy is extracted and added to the desired signal by virtue of the variable reactance of the diode shown in the center of Fig. 6(a).

Table I shows that the principal system limitation is likely to be antenna noise temperature; consequently, the less complex parametric amplifier should become popular for communications circuits.

3.4. Diversity. The detrimental effects of fast fades are reduced by combining a multiplicity of signal paths[17] which differ from each other either in antenna position (space diversity), carrier frequency (frequency diversity[39]), or the exact direction of the antenna beam (angle diversity[39,40]). This technique improves the median signals also but has no influence on climatic changes in signal strength or slow fades.

Polarization diversity is not very efficient as diversity,[9] but it is prevalent and contributes to the transmitter-receiver duplexing system.

As shown in Fig. 7 from Staras,[41] the benefits of diversity are statistical. For example, with quadruple diversity, the median signal is improved by 7 db, and the (weak) signal, exceeded 99% of the time, is improved by 19 db. Any signal correlation between the diversity channels reduces the diversity effect. As shown in Fig. 8 from Staras,[42] with a dual-switch diversity, the percentile signals (weak signal strength exceeded 99% of the time) would remain unchanged for a correlation of unity, but they would be reduced in occurrence to only 0.01% of the time with zero correlation. Note that an imperfect diversity technique with a correlation coefficient as high as, say, 0.6 or 0.8 is still quite useful.

The renewed interest in diversity stems appreciably from the fading in troposcatter.[17,43] Effort should be directed toward development of a diversity combiner intended for TV use in order to preserve the TV bandwidth during fades.

3.5. Controlled Carrier. Transmitters have been designed to ride through the deepest fade. They are thus overdesigned when there is little or no fading. By reciprocity, the slow fades will be the same in both directions of a circuit; consequently, the received signal level at a station may be used to control the transmitter output power at that station. See Fig. 9 from Yeh.[44] By such a means a station with a maximum average output power of 1 kw might consume primary power corresponding to an average power output of only 100 w. This is one of the several new variable-parameter or automatic circuits; others include variable bandwidth and variable time delay, which are described next.

3.6. Automatic Bandwidth Control for FM Systems. If the intermodulation noise in an ordinary FM system is quite normally comparable to the thermal noise, then, during periods of deep fade, the receiver bandwidth can be decreased, thus moving the threshold to a lower value of received signal power at the expense of increased intermodulation. In the "ABC" system,[45] this happens automatically. When the signal-to-noise ratio falls because of propagational factors, a second i-f stage controls a first variable-bandwidth i-f stage. This system, already feasible for multichannel voice communications, might possibly have some application to TV transmission by troposcatter. Similarly, the action of such a circuit might feasibly be improved by simultaneously controlling the transmitter bandwidth from signal level information derived at the local receiver.

3.7. Anti-Multipath. An anti-multipath device has been devised[46] for troposcatter voice-multiplex systems but has not been tried for TV. With this device several diversity channels each feed a post-detection combiner. Each channel also feeds a phase comparator, which compares the phase of the channel (before combiner) with the average for all channels (after the combiner). The comparison results in a correction of the delay in each channel, thus making the delay in all channels approximately the same. Consequently, the delay that causes multigraph fading is reduced substantially.

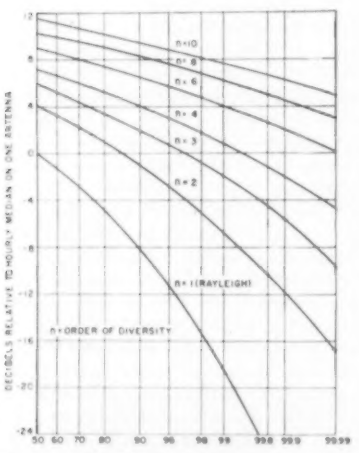

Fig. 7. Probability of instantaneous s/n exceeding ordinate.[41]

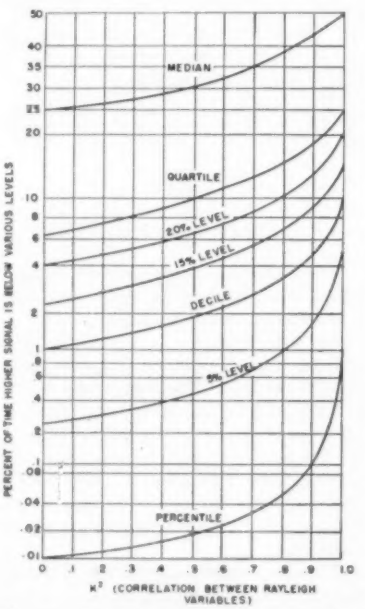

Fig. 8. Diversity with correlated signals.[42]

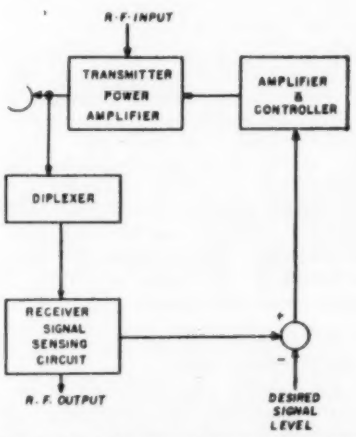

Fig. 9. Block diagram of controlled carrier system.[44]

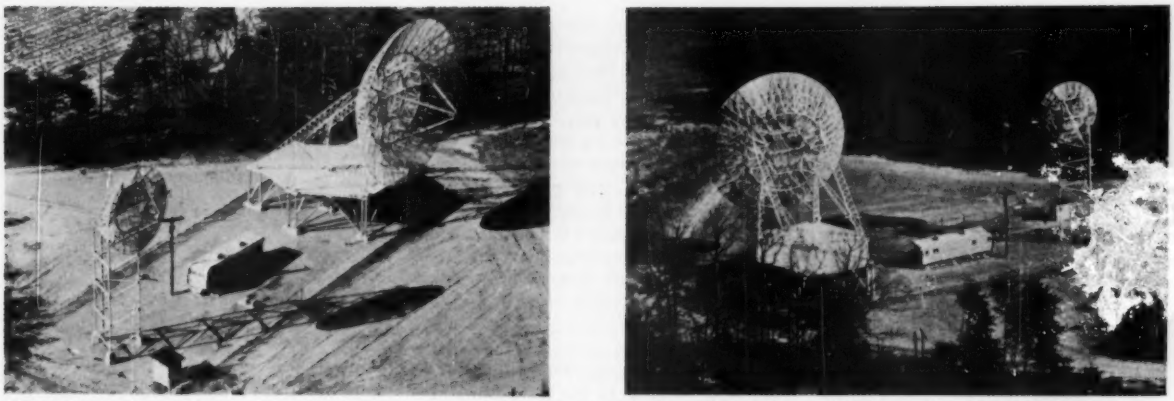

Fig. 10. Two views of experimental 615-mile tropospheric-scatter terminal employing 28- and 60-ft paraboloidal-reflector antennas. (Operated and maintained by Page Communications Engineers for Lincoln Laboratory.)

3.8. System Experience. Ranking with the industry's most important progress is its experience. Troposcatter circuit reliability is unquestionably good; even the first Texas Tower achieved 99.8% overall reliability for its troposcatter communications. This may be contrasted with HF point-to-point systems having reliability as poor as 50% over some paths. One new troposcatter system,* exceeding 600 miles in length, has been pronounced as propagationally highly reliable[47]; it is operated with a bandwidth too narrow for present TV, and with single-sideband modulation and automatic load control, but without certain advances such as the other variable-parameter circuits or the parametric amplifier. One terminal of a test system is illustrated in Fig. 10, which shows antenna comparisons in progress at Winston-Salem, N. C., and the compact test installation in a trailer.

Several troposcatter paths exceeding 500 miles have been tested at intervals along their course for path loss; the results were in rather good agreement; these included an overwater path[48] exceeding 700 miles. Installation problems have been solved all over the world, including arctic regions which, initially, posed difficult problems in logistics and construction.

The author's firm performed a tropospheric-scatter path-loss test and evaluation, conducted geodetic surveys, and collected weather data for the eastward extension of the DEW Line which will link the present terminal on Baffin Island in Canada with a point in Iceland 1200 miles distant (by multiple hops). Access was by airplane, ship and helicopter. Conditions of climate and terrain were even more severe than those encountered on the original DEW Line sites across the top of Canada. The firm's responsibility included procurement of survival materials and the training of personnel in the techniques of their use. Each team was completely self-sufficient and was accompanied by U.S. Air Force survival experts to ensure the least possible hazard. Despite the fact that much of the survey work was done atop an icecap nearly two miles thick, and under threats of devastating wind and snow storms which destroyed the facilities of one station, the task was successfully completed within the tight schedule imposed by the arctic summer (see Fig. 11).

Klystrons are in use up to 75 kw at around 400 mc, and around 10 kw at 1000 mc. Antennas of the "outdoor movie" variety are installed up to 120 ft in diameter; larger ones could be built but the expense indicates that we should look elsewhere for system improvement.

Parametric amplifiers are being installed in long-hop systems, for example, the DEW Drop system, which is in the same general region of one proposed NARCOM hop (departing east from Canada), and also a long hop from England to Spain.

Thus, while there are still problems to be solved for the intercontinental TV circuit, new technical contributions are being made steadily, and practical installations are utilizing them.

4. NARCOM System

4.1. Problems Posed by Intercontinental TV. In addition to the obvious problems of financing the construction and operation of an intercontinental TV system like NARCOM, and the governmental problems involved, a number of technical problems must be resolved before a real system is considered for installation. The list would include at least the following:

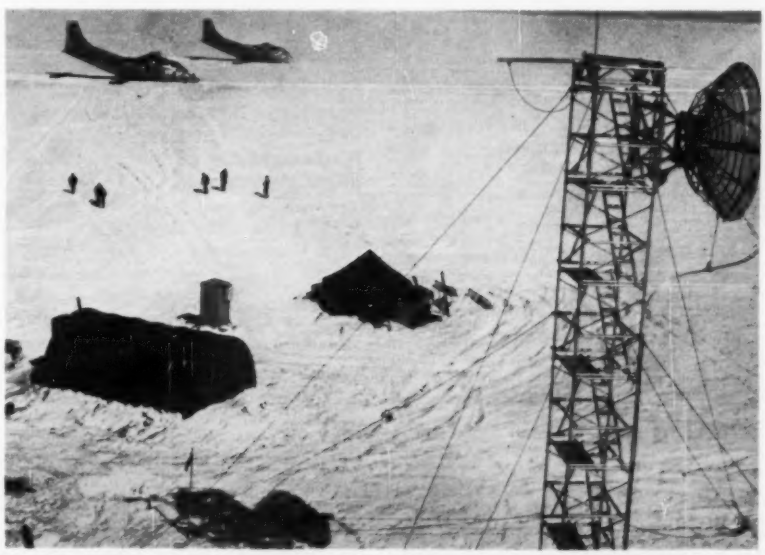

Fig. 11. Greenland's ancient sea of ice plays host to engineers mapping electronic paths through the arctic sky for DEW East. (Courtesy of Western Electric Co.)

* Recent troposcatter work by Page Communications Engineers includes: (a) Project Dew Drop, 638 miles, from Millstone Hill (near Lowell), Mass., to Sauratown Mountain (near Winston-Salem), N.C., under contract with General Electric Co. (installation, testing and operation); (b) Project Dewy Rose, 860 miles, from Round Hill (near New Bedford), Mass., to Dewy Rose (near Elberton), Ga., under contract with Lincoln Laboratory of MIT (operation and maintenance of Dewy Rose station).

(a) What is the extent of interhop correlation of short-term and long-term fades?

(b) What is the time distribution of antenna-medium coupling loss? And to what extent is this already a factor in the known distribution of long-term fades?

(c) What is the quantitative and also subjective effect of fast fading of (or loss of correlation between) the sidebands?

(d) What are the requirements for intermodulation?

(e) How much reduction of equipment bandwidth is feasible?

(f) What is the optimum combiner for preserving bandwidth during fades?

As previously stated, variable power, bandwidth and time delay could be important factors in realizing an intercontinental system. Other variables may be feasible; for example, if intermodulation limits or bandwidth requirements could not be achieved for some part of the time, then, during this time, the transmission rates could be slowed down and the bandwidth requirement reduced proportionately. The slowed signal could be stored until enough of it had been received to permit its release and broadcast at the original rate, or a slower and less perfect signal could be transmitted temporarily. As the progress of technical system accomplishments often includes variable parameters that gradually add to other increases in complexity to achieve improved results,† perhaps more troposcatter variables may be anticipated.

A Canadian group is sponsoring a NARCOM TV system by troposcatter, which will depend of the cooperation of the various governments concerned. The basic system design has been contracted to Page Communications Engineers of Washington, D.C.

4.2. Calculations for a Long System. Techniques exist for single-hop system loss calculations[30,41,49] which allow for all likely details of climate and terrain; but a completely delineated calculation for a complete TV troposcatter system has not yet been published.

Appendix I presents a means for determining the optimum number of stations in a system; it considers only the costs and the median path loss and assumes that all else is satisfactory.

Appendix II contains an abbreviated calculation, based on various assumptions, permitting a first appraisal of the kind of system factors involved. Within the framework of these assumptions, a system of 15 equal hops over a smooth earth could be produced with transmitter power output of only 280 w as calculated, or with more power as a safety factor.

† As an example, the Wright brothers' aircraft had one hinge per wing; commercial aircraft have two; the latest Chance-Vought fighter has five.

5. Conclusion

In summary, it may be well to advise that much new thinking exists beyond what has already been proved, and that this new thinking will be of real value after it has first been tried out on some good approximation to the long system. We have been asked repeatedly for a firm statement as to when intercontinental TV will be ready for installation, but no reasonably accurate date can be given in view of the desire for further development and testing prior to any such installation. This conclusion was perhaps stated best by a journalist[50] reporting on intercontinental TV at the 1958 Detroit meeting of the SMPTE: "... within technical reach ... ready for refinement and experimental application ... sooner or later ..."

6. Acknowledgments

Valuable discussions have been held with several members of the staff of Page Communications Engineers. Special thanks are due Ross Bateman, for ideas expressed from time to time. Others who aided similarly include Herbert H. Schenck, Joseph A. Waldschmitt, Charles A. Parry and Paul D. Rockwell.

APPENDIXES

I. Number of Stations in a Long System

The purpose of the troposcatter system is to utilize only a few stations for obtaining a long system. However, too few stations might be excessively expensive because of the great size necessitated for the transmitter and associated gear. Parry‡ has provided an approximation for determining whether a system of approximately n stations shall be of m or n stations. Based on his method, we have the following: Let d represent the system length in miles; let n stations, spaced d/n (or m stations spaced d/m) each cost $\$C_n$ total for the whole station; and let each be powered by W_n watts from the transmitter. Neglecting the fixed increment of signal loss, a variable increment of about 12 db/100 miles remains, together with slow fades that are less critical at long distances (see Fig. 3, Sec. 2.4 of text). These variables are approximated by 0.1 d/n db for d/n miles. The difference in decibels between 0.1 d/n and 0.1 d/m would have to be compensated by the same change in transmitter power, which fact we may write as:

$$10 \log \frac{W_m}{W_n} = \frac{d}{m}(0.1 \text{ db}) - \frac{d}{n}(0.1 \text{ db})$$

Now, for example, consider $d = 3000$ miles; suppose we try out $d/n = 200$-mile; and $d/m = 300$-mile hops. (This narrow range of n/m avoids a factor for accounting for the accumulation of noise vs. number of hops.) Then, $n = 15$, $m = 10$, from which $W_m/W_n = 10$ db. Since the m-station system has only two-thirds as many stations as the n-station system, the former (whole) stations could each cost 1.5 times as much as each of the latter stations, but each of the former would require 10 times as much transmitter output power. Whether this extra capital (50% per whole station) would pay for the extra power (10 db) would become a matter of cost accounting. In fact, only if the stations were of low enough power could the 50% pay for the extra 10 db, and thus result in fewer stations being used at the same total cost. This reasoning can be extended to any numbers in question for m or n.

It is possible to produce an implicit equation for the number of hops X, but this will prove cumbersome to use. For a transmitter power of W watts, let CW^n be the cost per hop of all transmitters and those items whose cost varies in proportion to transmitter power. (C and n are arbitrary constants determined from suppliers' prices.) Let the cost of all other capitalization for the system be B; then for a total system length of P miles, X can be solved by trial and error from an implicit equation of these variables. One form of such an equation is:

$$\frac{B}{C} = e^{2.76 P n / X} \frac{P^{2n}}{X^n}\left[\frac{2.76\ Pn}{X} - n - 1\right]$$

where $e = 2.718$.

‡ C. A. Parry, private memorandum.

II. Calculation of Transmitter Output

With enough assumptions we can calculate a sample transmitter power-output requirement.

Assume a 1000-mc system, length 3000 miles, 15 equal hops. In order to assign a value to the angle θ, we have to assume some kind of terrain; we chose a perfectly smooth earth which in some cases would be optimistic, but which in many other cases can be realized (or even improved upon by elevated sites); we assumed a climate with equivalent earth radius of 4/3, and quadruple diversity.

The type of modulation system was ignored and the i-f bandwidth was assumed to be 1 mc.

For the combined effect of the fast and slow fades we simply accounted the fast fades as part of the subjectively required value of signal-to-noise ratio.

A few expected losses or unknowns were ignored in the calculations but may balance out; otherwise they would still have to be accounted for:

(a) Transmission line loss from transmitter to antenna.

(b) Uncertainty of 3-db gain in a ratio-squared combiner, including the uncertainty of even using that kind of combiner.

(c) Probable error in the calculations.

(d) Possible degradation of system components.

(e) Although the literature[20,21] indicates the necessity of 38-db signal-to-noise Rayleigh fading, this value may need correcting for diversity circuits and for tandem circuits.

(f) The correlation of slow fades is assumed at unity (maximum depth of fade simultaneously on all hops for 1% of the time). The other extreme would be zero joint probability distribution (one day fade at a time for 15 times as much total duration). In practice, the answer falls between these extremes.

While IM (intermodulation) requirements for TV are not critical, the IM should be minimized to permit the system to be used for other more critical purposes during the periods when there is no TV transmission.

The possibility of a system with hops of 300 miles instead of 200 miles depends upon obtaining another 10 or 12 db of signal-to-noise ratio. This can be obtained in the foreseeable future by the use of some combination of the following:

(a) further resolving the safety factor required,

(b) larger antennas,

(c) diversity system of an order greater than 4,

(d) diversity combiner designed for this specific purpose,

(e) much larger transmitters,

(f) additional reduction of bandwidth requirements below 1 mc at i-f, and

(g) additional reduction of effective system noise figure, accomplished by improved antenna siting and receiver input circuit should result in a noise temperature much less than 290 K (see Table I).

The calculation for 200-mile hops is shown in Table II.

Table II. Calculation for 200-Mile Hops.

1. *Median path loss, nondiversity*		
Assume 15 hops in 3000 miles, and a smooth earth with radius of 4/3. Then (from Ref. 20, Sec. 2.6 of text), θ =	33.8 milliradians	
From this (applied as in Ref. 13, Sec. 2.2 of text), the basic median path loss between isotropic antennas is 209 db for winter afternoons, and for the whole year average it is		−205.5 db
The total free-space gain of two circular paraboloidal antennas, each of 120-ft diameter, at 1000 mc, is		+ 98.0 db
Antenna-medium loss for this circuit would be about		− 7.5 db
		−115.0 db
2. *Long-term path loss, with diversity*		
Quadruple diversity with zero intrahop correlation, and with ratio-squared combiner, produces a median signal gain (from Fig. 7, Sec. 3.4 of text) of	+7.5 db	
Assume a system long-term reliability of 99%.		
For one hop, this requires a long-term fade margin (Fig. 3, Sec. 2.4) of 11 db. For simplicity and conservatism, the present calculation assumes a correlation of unity. Thus for 1% of the time all hops require a fade margin of	− 11.0 db	
Consequently, the long-term net path loss is		−118.5 db
3. *Noise*		
Thermal noise or kt* per cycle is	−204.0 dbw	
The i-f bandwidth will be assumed to be reduced to 1 mc. This factor of 10^6 is	+ 60.0 db	
The effective noise figure (includes sky and earth noise received by the antenna) is assumed to be	0 db	
Thermal noise in one hop is therefore		−144.0 dbw
Per watt transmitter, the carrier-to-noise ratio per hop is		+ 25.5 db
Fifteen hops alter this by 10 log 15 =	− 12.0 db	
Making a total of		+13.5 db
Neglecting modulating-system improvement factors leaves a long-term signal-to-noise ratio for 1-w power transmitted of		+13.5 db
4. *Power*		
The hourly median signal-to-noise ratio required for good signal with Rayleigh fading has been measured (Refs. 20, 21, Sec. 2.6 of text) as		+38.0 db
Thus, the required increase in transmitted power, over 1-w, is		24.5 db
This is a power output from the antenna of		280 w

* k = Boltzman's constant; t = temperature in degrees Kelvin, assumed 290 K for standardized noise figure calculations.

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An Improved Image Orthicon

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The 3-inch image orthicon has certain limitations, mainly associated with target structure. The 4½-in. image orthicon was developed with the intent of overcoming these limitations while retaining the sensitivity of the 3-in. tube. Among the new tube's operational advantages are higher signal-to-noise ratio and better resolution.

When television service in Britain was resumed in 1946 no newly developed equipment was available since all work in this field had been suspended for the period of the war. It was recognized that not only would new cameras be needed but also that if the scope of television was to expand at a reasonable rate then a completely new pickup tube would be necessary. The old image iconoscope had, it was thought, reached the end of its development and it was still of inadequate sensitivity. The full theoretical sensitivity of the tube could never be realized as long as high-velocity scanning and its attendant short storage time was employed.

The low-velocity full-frame storage orthicon adopted for general use showed some increase in sensitivity following the introduction of a new technique for making photosensitive mosaics from antimony/caesium, but the tube needed special lenses[1] to exploit its large photocathode and it was extremely unstable to overexposure. This adverse characteristic, now minimized by new circuitry and photoelectric target techniques, led us to consider ways in which the other low-velocity camera tube, the image orthicon, could be improved. Its main drawbacks to producing "good" pictures were noise, black halo around highlights, poor definition, inability to produce true edge transition, etc. These faults tended to offset the advantage of sensitivity which the tube possessed over its contemporaries.

Schade, in his classical work of 1950,[2] had indicated the most profitable lines on which this tube was capable of improvement and it was one of his early designs which the authors' company adopted as a basis for development.

The limitations of the 3-in. image orthicon are mainly associated with target structure and can be summarized:

(1) marginal signal-to noise ratio;

(2) spurious effects due to redistribution of secondary electrons on the image side of the target, and to the existence of interelement capacitances — (a) halo, (b) white edging and (c) unstable transfer characteristic.

The purpose of this paper is to examine these parameters and discuss practical means for their improvement.

The signal-to-noise ratio of an image orthicon bears a simple relationship to the charge stored at the target. It can be shown that

$$\text{signal-to-noise} \simeq \sqrt{q}$$

where q = charge stored at target.

Three methods of increasing the stored charge and consequently signal-to-noise ratio, are possible:

(1) increase target mesh capacitance by the reduction of target glass–mesh spacing,

(2) increase target mesh potential, and

(3) increase target capacitance by increasing its area maintaining the spacing at its former value.

Methods 1 and 2 can and have been applied to the 3-in. image orthicon but such tubes are still deficient in many ways.

Method 1 is not satisfactory as, apart from introducing manufacturing difficulties, a decrease in target spacing leads to increased microphony and under certain operating conditions, picture lag. Furthermore, the increased charge stored must be transported through a film of the same area which causes a reduction in useful tube life due to the early onset of burn-in. Burn-in is an electrochemical process intensified by high charge density and is thought to be due to polarization producing a high resistance film on one face of the target glass.

Limitations at High Target Potentials

Severe limitations are imposed upon operating image orthicons at high target potentials. The resulting high potentials on the scanned side of the target produce spurious effects caused by the deflection of the scanning beam away from its intended point of target incidence. Ballooning of whites and diffuse edges are but two of these troubles. As explained later, these effects can be reduced by increasing the target decelerating field of the scanning beam by incorporating a field mesh. This mesh has been a feature of E.E.V. Co.'s 3-in.

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image orthicon for the past nine years. The work of Theile[3] together with the recent evaluations of the type 7293 in Canada and the U.S. have demonstrated the advantages of this mesh.

The operation at high target potential has the same effect on tube life as reducing the spacing of target and mesh.

The remaining method of increasing the target capacitance and hence the charge stored, that of increasing the area without a change in spacing, is not subject to the limitations mentioned above. The increase in the area of the glass film reduces the charge density and for the same picture element capacity the useful life of the target will be increased.

The use of a larger target thus provides a means of increasing the storage capacity and hence signal-to-noise ratio, without an adverse effect on life expectancy.

The capacitance of the larger area target remains a function of the target mesh spacing and by reducing this it is possible to increase the target capacitance by a factor of over 50 with respect to the low-capacitance 3-in. image orthicon, types 5820 and 7293. However, with capacitances of this order other limitations arise. Due to the high charging currents needed, sensitivity is reduced and capacitance lag occurs due to the difficulty of discharging the target in one scan. Tubes with targets of this high capacitance have been made and have achieved success in particular applications. E.E.V. Co.'s P.812, for instance, is used for systems conversion where sensitivity is not at a premium and the lag introduced by the monitor is greater than that of the pickup tube. Attempts have been made to use this tube for normal broadcast purposes but it proved unacceptable for reasons of lag and inadequate sensitivity.

It was thus necessary to fix the spacing of the larger area target to give a capacitance intermediate between that of the low capacitance types 5820 and 7293 and the extremely high capacitance P.812. To arrive at an acceptable value it is necessary to consider the mechanism of charge storage in greater detail.

As stated above, one of the most serious objections to the low-capacitance tube are effects such as white edging. These effects are known to be due to the presence of charge storage capacitance, additional to that between target and mesh, actually in the plane of the target itself. Wherever a surface potential gradient exists then that area behaves as a minute condenser. The presence of this capacitance helps to accentuate edges and improve the subjective sharpness of the picture produced by the tube. It is now acknowledged, however, that this type of quasi three-dimensional picture is unrealistic and unacceptable.

The contribution of these additional surface capacitances to picture quality depends on:

(1) their magnitude relative to the main target/mesh capacitance, and

(2) whether the degree of tube exposure is sufficient to charge them or not.

To develop the argument it is convenient to postulate the existence of a target picture "element," this element having a size which will be determined by the bandwidth and the line frequency of the television system.

Cm will denote the capacitance of the element to the mesh and Ce the coplanar capacitance of the element to its surrounding areas. Cm is a simple function of area and is always present. The effect of Ce, on the other hand, is dependent entirely on the target charge distribution. It can exist only at points where some charge gradient has been created and will be proportional to this charge gradient. At points corresponding to a black-white transition, therefore, the effect will be greatest, and at these points the additional capacitance will be effectively in parallel with the main mesh capacitance. In areas uniformly charged Ce will be noneffective. The total effective storage capacity of an element will be then:

$$Cp = Cm + Ce$$

$$\text{i.e., } Cp = Cm\left(1 + \frac{Ce}{Cm}\right)$$

An alternative approach by Rotow,[4] assuming a series/parallel combination of capacitances, derives the expression

$$Cp = Cm + \frac{Cm}{1 + \frac{Cm}{Ce}}$$

In either case it is seen that if a picture is to be substantially free from edge effect then Ce/Cm must be as small as possible. It is not merely a question of reducing Ce, Cm must be made as large as possible in addition.

Solution to Edging Effects

The edging effects due to the interelement capacities are particularly marked in the case of the low-capacitance 5820 and 7293 tubes due to the mode of operation necessitated by the marginal signal-to-noise ratio. An image orthicon which is exposed to the point where only the element mesh capacitances are charged, or in operational terms exposed to the knee, has a gamma of unity and this is considered unsatisfactory due to the high gamma of the display tube. It is possible to optimize the overall gamma of the 5820 and 7293 types by increasing the exposure but this cannot be done without introducing the interelement capacitance edges and redistribution effects.

The alternative solution, to operate the tube in the condition of reduced exposure so that the interelement capacitances are not charged, while correcting the transfer characteristic by the use of a nonlinear amplifier, is not possible because the signal-to-noise ratio of the tube output is low. For color work where strict gamma control is essential resort has been made to the 3-in. 7294 type of tube where the improvement in signal-to-noise ratio has allowed some measure of electronic gamma correction.

Table I. Target Characteristics of Various Types of 3-In. and 4½-In. Tubes.

Type	Target spacing, in mils	Element mesh capacity	Signal-to-noise improvement	Ratio Ce/Cm
5820/7293	2	Cm	0	1
6474/7294	0.65	$3\,Cm$	+4.3 db	0.33
7295	2	$3\,Cm$	+4.3 db	0.54
7389	1	$6\,Cm$	+7.8 db	0.27
P.812	0.2*	$30\,Cm$*	+15 db*	0.05*

* Estimated.

For improved performance then, the target structure has to meet the two requirements: (1) Ce/Cm to be small; and (2) Cm to be large.

As the result of these considerations and tests by various broadcasting authorities two 4½-in. tubes have been made available with target areas three times that of the 3-in. tubes. These are: type 7389, high-capacitance target; and type 7295, medium-capacitance target.

It is instructive to consider the target characteristics of these two types and of the P.812 mentioned above relative to the existing 3-in. tubes, taking the ratio Ce/Cm for the 5820 as unity (Table I).

Element mesh capacitance increases proportionally with target area whereas the interelement capacitances are proportional only to the linear dimension so the ratio Ce/Cm is decreased for a larger target.

From the above figures the relative performances of the tubes can be predicted and in actual tests are adequately confirmed.

It can be argued that type 7389 is only marginally superior to the close-spaced 3-in. types 6474 and 7294 as regards interelement effects. However, the value of Cm for type 7389 is considerably better than that for these two types and, as explained in detail below, the adoption of the larger area confers further advantages.

Spurious Effects Due to Redistribution

The charge pattern on the target is created as a result of secondary electron emission produced by the incident photoelectrons from the photocathode. In theory the secondaries are collected by the slightly positive target mesh. In practice, in target areas under high photoelectron density the target rapidly assumes a potential above that of the adjacent mesh and the secondaries are no longer collected. They are able to return to areas only where there exists

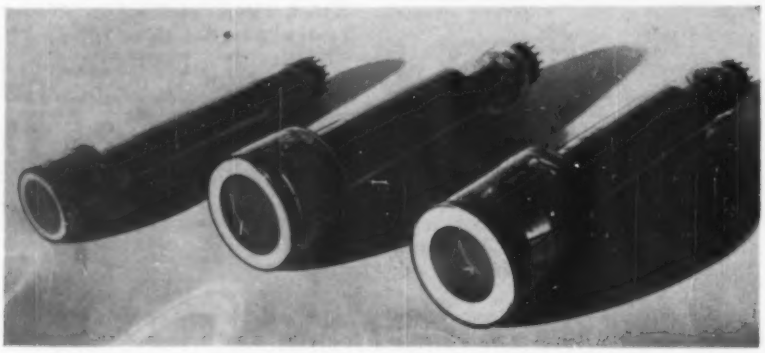

Fig. 1. Showing from left to right a "standard" 3-in. image orthicon, a 4½-in. scaled-up version and its modern counterpart.

a less negative field gradient, i.e. incompletely charged areas on the surrounding target. The energy of these redistributed secondaries is insufficient to cause further secondary emission and they are deposited as negative charge which of course corresponds to picture black — producing the familiar image-orthicon halo. Under controlled exposure conditions these redistributed electrons have some advantage inasmuch that poor contrasting picture detail is rendered more easily visible. However, the halo effect is most disturbing and it can, except for most intense speculars, be completely eliminated by correct exposure in the 4½-in. tube.

It is easy to see that the magnitude of the halo effect will be determined by the distance the uncollected low-velocity secondaries travel before they land again on the target and it is not unreasonable to assume that this distance will be proportional to the spacing and, for any given value of spacing, it will be a constant amount. It follows, therefore, that with a larger closer-spaced target, the redistribution spread will be a smaller fraction of the picture information and, consequently, less annoying.

The authors believe also that redistribution electrons are responsible for the relatively unrealistic picture appearance produced by wide-spaced small target tubes, and also for the instability of the transfer characteristic. With 4½-in. tubes the relation between signal output and light input is substantially independent of picture content at optimum exposure, and furthermore, due to the higher capacitance, is linear over a greater contrast range.

A further advantage forthcoming from the adoption of the larger storage surface in the 4½-in. tube is an improvement in resolution. Since it is possible to maintain the same target thickness, the ratio of lateral conductivity to signal transfer of the target is reduced relative to that of the target of the 3-in. tube. A simple mathematical analysis illustrates this point. If one considers an element of target, the conduction Gv, from face to face for a given thickness is proportional to the elemental area or the square of its linear dimension.

$$Gv = kA = k_2L^2$$

Transverse or surface conductivity, G_s, is a function of its peripheral length or k_3L

$$\frac{Gv}{Gs} = \frac{k_2L^2}{k_3L} = k_4L$$

Thus, the ability of a target to transfer elemental charge between its faces without sideways leakage is solely dependent upon the elemental width. The diagonal of the 4½-in. image-orthicon target is approximately 1½ times that of the 3-in. tubes and the increase in resolution is as expected. The operational advantages of a large, high-capacitance target then can be summarized as follows:

(1) higher signal-to-noise ratio,
(2) longer burn-free life,
(3) greater freedom from edge effects,
(4) greater freedom from redistribution troubles,
(5) longer linear transfer characteristic, and
(6) better resolution.

These benefits are not obtained without difficulties, and it is timely to touch upon some of these and outline the remedies which have been found.

The larger target in circular form has a greater tendency to free vibration or microphony, and it is necessary to introduce special rectangularly situated spacing strips[5] to destroy this circular form and additionally reduce the target chord which can vibrate — so increasing the natural frequency to a less objectionable value. Current 4½-in. image orthicons are probably less susceptible to mechanical and acoustical vibrations than contemporary 3-in. tubes, but work on further reducing this susceptibility is continuing.

Scanning a larger target demands a larger diameter tube barrel, which in turn introduces a greater difficulty of ensuring linear and uniform beam landing conditions over the whole target area. However, acceptable performance is obtained by including the well-tried feature of 3-in. series of tubes — the field terminating mesh. In the 4½-in. tube, however, advantage was taken of its novelty and the field mesh voltage supply was separated from that of the focusing electrode. It was thus possible to arrange that the focusing electrode was held negative with respect to the mesh thus suppressing the secondary electrons produced there by the scanning beam as it was intercepted. In the early 3-in. tube it had not been possible to arrange a separate field mesh supply since no additional tube electrode supplies were available in the many existing operational cameras. It may be mentioned in passing, however, that in the last year secondary electron suppression has been achieved in the 3-in. tube by the incorporation of a special suppressor electrode.[6]

In addition to straightening out the electrostatic field on the scanned side of the target, the field mesh has other important functions. By raising its potential the spurious signals due to beam bending are considerably reduced and the advantages of higher target potentials can be exploited. Theile has confirmed[3] that geometrical distortion of sharp contrast edges is much less objectionable in tubes using a field mesh.

The uniform decelerating field in field mesh tubes being substantially free from radial components ensures that the path of the return beam almost coincides with its forward path and that, in consequence, the scanned patch on the first dynode is considerably smaller than in non-field mesh tubes. The ratio between dynode blemish size and picture information and beam size is thus increased, rendering the former much less objectionable since its contrast is reduced. Furthermore, the smaller scanned dynode area ensures a more uniform collection of secondary electrons from the first dynode and should defocusing be desirable, it can be achieved with an imperceptible drop in resolution.

It was desired for optical reasons that the photocathode in the 4½-in. series of tube would remain identical in size and nature to that used in the 3-in. tubes, while providing the possibility of using a size equal to that of the target if needed. In order, therefore, to fill the target with the electron image from the smaller standard cathode it was necessary to arrange in the camera a divergent magnetic field from photocathode to target in such a way that the linear photocathode dimensions are multiplied approximately 1.5 times. This electron-optical magnification was rendered technologically easier by increasing the length of the image section, to give an increase in target area three times greater than that of the 3-in. tube.

Figure 1 shows the relative sizes of a standard 3-in. tube, a 4½-in. scaled-up version of the 3-in. tube and a sample 4½-in. tube of current manufacture. At first sight this dilution of charge may seem to indicate a reduced sensitivity of 3 : 1 for the 4½-in. tube but since its optimum operating point is say, two lens stops below that of the 3-in. tubes, no drop in practical sensitivity results.

Table II. Relative Performance Characteristics of 3-In. and 4½-In. Series of Image-Orthicon Tubes.

Tube type	Signal-to-noise ratio	Center resolution	Corner resolution	Edge effect: up to
Low-capacitance 3-in. types 5820 and 7293	30 db	−11 db	−12 db	40%
High-capacitance 3-in. types 6474, 7294 and 7513	34 db	−11 db	−12 db	25%
Medium-capacitance 4½-in. type 7295	35 db	−5 db	−7 db	8%
High-capacitance 4½-in. type 7389	39 db	−5 db	−7 db	4%
Ultrahigh-capacitance 4½-in. type P.812	42 db	−4.6 db	−7 db	1%

Notes: (1) The values of signal-to-noise ratio are actual figures averaged over a large sample of production tubes. The ratio is given by the formula — signal-to-noise in dbs = 20 log 6(peak white signal amplitude)/(peak to peak noise amplitude). (2) Resolution is measured as the relative amplitude response of a 400 TV line pattern to a true black/white transition. (3) Edge effect is the approximate percentage overshoot at a black/white transition in the scanning direction. (4) Each of these measurements is made on equipment having an amplifier bandwidth restricted to 5.1 mc and flat within ±0.25 db up to that frequency.

Two Focus Potentials

The revised electron optics of the 4½-in. tube image section allows two focus potentials for the primary photoelectrons each of which will give satisfactory geometry — the main consideration in any image converter. It is preferable, however, to use the highest focus node since the higher energy photoelectrons give increased gain at the target and hence greater sensitivity. Furthermore, the high energy photoelectrons are less affected by any leakage fields from the scanning coils and suffer less from aberration due to velocity spread and better resolution results. Probably most important of all, the increased penetration of the photoelectrons into the target utilizes a greater volume of sodium ions for carrying the charge to the scanned side of the target. This retards the formation of the ion-free insulating layer which is responsible for burn-in.

The relative performance characteristics of the 3-in. and 4½-in. series of image-orthicon tubes are given in Table II.

The only operational disadvantage of the 4½-in. tube is its size, but this, as the companion paper by Partington shows,[7] has proved no disadvantage in the new Marconi Mark IV Camera.

Operationally the 4½-in. tube differs very little in principle from the 3-in. tubes. One notable exception is the potential of the target mesh. It was argued earlier that high target potentials in "standard" 3-in. tubes were undesirable for many reasons. In the 4½-in. tube, however, the difficulties introduced by high target voltages are less severe and Brothers[8] of the BBC shows that a distinct improvement in overall performance is obtained by an increase to about 3 v. Other operators choose values varying between 1.5 and 3.5 v according to the degree of contrast used in set design, etc. The authors believe that a contrast range in picture brightness of approximately 50 : 1 gives optimum results, but if larger values are unavoidable or if bright speculars exist an increase in mesh potential may be advantageous. The target mesh, incidentally, is of superfine pitch and cannot be resolved nor can it cause moire or beat pattern with aperture correction in any of the television systems in current use.

The absence of spurious signals from the 4½-in. tube allows pictures of exceptional quality to be produced and a little extra care in the setting up procedure is amply repaid in the appearance of the final picture-tube image. A technical information leaflet for the type 7295 has been prepared with fifteen steps outlined as the practical procedure recommended for operation.

Acknowledgments

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The Design of a 4½-Inch Image-Orthicon Camera Channel

By GEORGE E. PARTINGTON

The 4½-in. image orthicon was introduced in 1955 as a contender with various European camera tubes for top picture quality with maximum operational flexibility. Its special characteristics are considered, particularly by comparison with 3-in. tubes, in a companion paper.[1] The way these influence the camera channel design is illustrated with reference to a new 4½-in. camera channel which combines maximum performance with a greatly reduced operating effort.

A SIGNIFICANT feature of postwar television development in Europe is the degree to which competition among equipment manufacturers and operating organizations has as its objective better picture quality. Pursuit of this objective is often hampered by difficult lighting requirements, heavy lighting and ventilation loads and other operational restrictions; but there has been incentive for the continuous development of better camera tubes and equipment. The situation led Marconi's Wireless Telegraph Co. in 1951 to adopt the 4½-inch image orthicon as a contender for top picture quality in competition with the cathode potential stabilized orthicon and various types of the super iconoscope.

The present 4½-inch tube was introduced in 1955 and there are now over 300 cameras using it. The 4½-inch tube is almost universally used in Great Britain and is also widely used in Canada, Australia, Italy, and to an increasing extent in several other countries. The contribution of the 4½-inch tube to improved picture quality is perhaps even more marked in remote broadcasts than in the studio.

D. C. Brothers[2] has pointed out that the improved vertical resolution of the 4½-inch tube should also lead to better fringe area reception, since this is less easily degraded than the horizontal resolution.

Various nonbroadcasting applications of the 4½-inch tube have been under development for some time, many of them stemming from its high limiting sensitivity. The improved signal-to-noise ratio and resolution allow useful pictures at only a few milli-footlamberts highlight brightness at $f/1$. Of particular importance is its use as an x-ray image amplifier in fluoroscopic work. Photographic or video-tape records can be made and the use of additional monitors facilitates consultation and instruction. For this use a special 4½-inch image orthicon has been developed with even greater sensitivity.[3] Visual-landing flight simulators are another field of application. These require a camera with enormous depth of focus and thus a high-sensitivity tube.

Effect of the 4½-inch tube on camera channel design can be summarized under three main heads:

(1) It is a big tube and the customer wants small cameras.

(2) A higher order of optical, mechanical and circuit engineering is required to match the superior tube performance.

(3) Performance is less marginal than that of the 3-in. tube and therefore more stable, so it is incumbent upon the designer to provide equal or better circuit stability.

By eliminating constant adjustment, operating conceptions are modified and equipment design changed accordingly.

There are other design objectives including:

(1) A camera as simple to operate as a motion-picture camera. This objective includes the removal of electrical controls from the camera, other than those for the viewfinder.

(2) Simple conversion between 525/625/405 standards, of particular importance for video tape. Includes operation on line voltages nominally 100/125 and 200/250, 50/60 cps.

(3) Easy conversion to 3-in. tubes.

(4) Suitability for either studio use with consoles and cabinet racking, or remote service with portable boxes.

(5) Facilities for the precise setting up and checking of the channel from the control room, without requiring assistance at the camera.

(6) All electronics to be easily replaceable in blocks.

(7) All components to be easily accessible while operating.

(8) All controls, including the presets, to be easily accessible, preferably on the control panel.

(9) Illuminated control panels for use in low ambient lighting.

Presented on October 8, 1959, at the Society's Convention in New York by George E. Partington, Marconi's Wireless Telegraph Co., Ltd., Television Laboratories, Pottery Lane, Chelmsford, Essex, England.
(This paper was first received on September 28, 1959, and in final form on January 28, 1960.)

Camera Size and Weight

A dimension comparison between 3-in. and 4½-in. tubes is made in Table I. The increase in image-section length allows the increase of focus field, necessary at the photocathode to give magnification onto the large target, without an undue pile-up of ampere-turns there, and without extending the coil much beyond the photocathode — which would increase the minimum focal length of the lens that could be used.

Table I. Dimensional Comparison of 3-In. and 4½-In. Image Orthicons; Dimensions in Inches.

	Length			Diameter	
	Total	Image section	Scanning section	Image section	Scanning section
3	15.2	2.6	12.6	3.0	2.0
4½	19.5	5.6	13.9	4.5	3.1

The 4½-in. image orthicon is without doubt a big tube, requiring a big and heavy focus and deflection system. The scanning coils look like something out of a small alternator but much work has gone into reducing the weight and diameter of the yoke, with quite useful results over the years.

The Mark III camera, with the 4½-in. tube, weighs 170 lb without lenses, and measures over the main body 27 by 16 by 15 inches. By any standards this is a large and heavy camera, but at the time of its design it represented the best possible design.

The first objective in designing a new 4½-in. camera was to reduce the weight and size. The Mark IV camera is shown in Fig. 1, and Table II makes a comparison with the Mark III and some 3-in. cameras.

The density figures are of particular interest. Such techniques as the extensive use of magnesium for strength and lightness had already been exploited in the Mark III, so the only remaining way to make a smaller camera was to put less in it.

On the circuit side, the number of tubes in the camera/viewfinder has been reduced to nine, plus two small high-voltage rectifiers and two small stabilizer tubes. This has been made possible by circuit developments giving better performance with fewer tubes, and by sending the field scan to the camera. A significant reduction in the size and

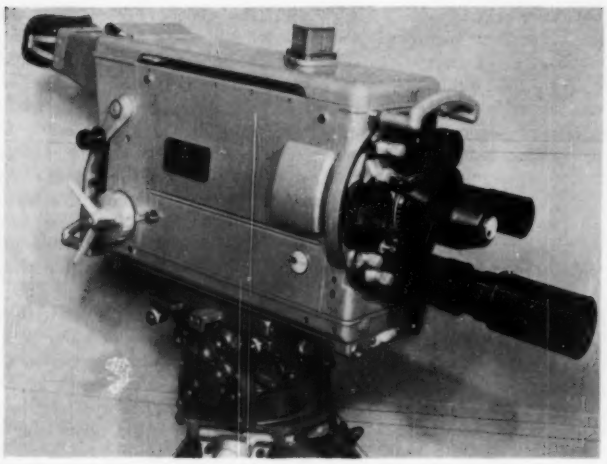

Fig. 1. Mark IV Camera.

Fig. 2. Changing the image orthicon: also shows access to camera circuits.

weight of the tube heater-transformer follows the reduced number of tubes.

As in the rest of the channel, all circuitry is in the form of plug-in printed wiring boards. They are mounted on the flap-down side covers so that access is excellent.

Turret and Focus

Optical flexibility is obtained by using a comparatively large (8½-in. pitch circle diameter) turret with four lens positions. A five-position turret was considered, to allow the permanent installation of a diascope, but the idea was rejected because of the increased interference between lenses of short and long focal lengths. Instead, simplified diascope mounting is provided. Interference is further reduced by folding long lenses away from the optical axis. The lenses are held by simple and rugged twist catches as in the Mark III. The standard range of focal lengths is 1.4 in. to 40 in., i.e. 50° to 2° horizontal viewing angle. Two passages are provided through the camera body for zoom or other controls.

The turret need only be removed from the camera for maintenance, and this makes it relatively easy to avoid free play in any direction. To change an image orthicon, the front of the camera is jacked up by turning a small handle at the side and access to the base is obtained by removing a cover at the back of the camera (Fig. 2).

Rotation of the turret is by a cranked handle, conveniently located above the focus knob; the handle works a new folded Geneva mechanism which has the desired nonlinear acceleration characteristic and gives very accurate self-indentation without the need for auxiliary devices. Furthermore, it is small, light, simple and it automatically takes up any wear, unlike the true Geneva and most alternative mechanisms.[4]

Table II. Comparison of Mark IV With Mark III and Some 3-In. Cameras Complete With Viewfinder, Tubes, etc., but Less Lenses.

		Main body				
	Weight, lb	Length, in.	Height, in.	Width, in.	Volume, cu in.	Density, lb/cu in.
Mk. IV 4½-in.	98	25	16	9½	3800	0.0258
Mk. III 4½-in.	170	27	16	15	6500	0.0262
A, 3-in.	120	22	17½	10½	3940	0.0304
B, 3-in.	120	21	18	12½	4720	0.0254
C, 3-in.	105	22½	13½	12	3640	0.0289

The image orthicon yoke is located in the lower half of the camera to facilitate low angle shots and to keep down the center of gravity. In effect, it occupies 40% of the camera volume. The yoke is mounted on a carriage with very simple self-aligning Teflon bearings sliding on chromium-plated tubes. This arrangement has the considerable advantage of negligible static friction and maintenance. It is driven by a cosine motion so that fine control is provided near infinity focus and the operator can adjust the system friction while focusing by a finger-tip control which also is used to lock the yoke position.

The capstan-type focus handle makes 720° rotation for maximum travel. It is adjustable in two steps to suit operational requirements. The capstan can easily be removed leaving a conventional focus knob.

Electrical connections to the yoke are by plug and socket and in fact the yoke can be removed entirely in a few minutes. Adjustments are provided to collimate the tube and lens.

Image-Orthicon Temperature Control

Image orthicons are designed to operate at a particular temperature of the target where the glass has the optimum resistivity. Accordingly, the Mark IV has a temperature control system using a small blower which takes in air through a filter and heating system and discharges it around the target section of the tube. A mercury contact thermometer indicates the temperature near the target and controls the blowing/heating system so that when the camera is first switched on, the heater and blower are on. This quickly warms the tube so that it is ready for rehearsal use in about 15 min. At 38 C the heater switches off and the blower slows down. If the tube tries to rise above 45 C, the blower speeds up, or if it cools below 38 C, the heater comes on again.

For standby, the image-orthicon cathode heater can be switched off and this switch also removes the line scan and the high tube potentials but the thermostatic control continues so that the tube is ready for immediate use, as is the rest of the channel, since this is not switched off.

Heat dissipation in the rest of the camera is low and natural ventilation is sufficient.

Exposure Control

Although the image orthicon exhibits considerable latitude in respect to exposure, it has long been recognized that optimum picture quality can only be obtained with correct exposure. Exposure control is now considered to be the fundamental operating control.

Exposure in the Mark III camera is

controlled by the video operator who remotely adjusts the rotation of a disc having a graded neutral filter between the lens and the camera tube. This method works well and is an easy solution for the camera designer, but experience shows that it leads to a loss of operational sensitivity of at least one stop. This is because the operator always wants some filter in, just in case he wants to take it out. When related to studio lighting and ventilation loads this loss is significant. Accordingly the Mark IV camera reverts to exposure control by varying the lens iris by the video operator. This discards the operational facility coming from depth of focus being constant if exposure is controlled by the neutral filter. This facility is largely a studio problem and the variation of iris required to take up lighting variations is not likely to produce as large changes of focal depth as the changes to lenses of different focal length. Iris control always provides the maximum depth of focus for the available light.

A filter turret is also provided behind the main turret, controlled by a slide knob along the camera side (Fig. 1) and adjustable to "capped," "open" and any of three different filters which can be neutral or color filters. Depth of focus can be lost by putting in a neutral filter, allowing the lens to open up.

The earlier 4½-in. camera used only a switch control with meter indication to vary exposure, but with the elevation of this to the major control, the Mark IV uses a full positional servo control by a knob calibrated directly in *f* or T numbers. The sensitivity is about 20 increments/stop. Special lenses have been developed with the iris controlled by a gear ring which engages with a central gear in the turret, driven by the servo system. Furthermore, the lenses are devised so that there is the same iris ring rotation between each stop so that the control sensitivity is constant, and the same for all lenses to allow direct calibration of the control knob. Lenses available include those developed by Taylor, Taylor & Hobson specifically for television and their studio zoom.[5,6] These are computed for image-orthicon use and to give the best resolution up to the limits of the television system with a fairly rapid fall afterwards rather than a slower drop off in response starting at a lower frequency. Vignetting and contrast are also carefully controlled.

All irises are driven together so that when the turret is operated the new lens is at the same stop as the old one was.

Viewfinder

A 7-in. rectangular kinescope with electrostatic focus but magnetic deflection, of course, operating at 12 kv provides a high-resolution bright picture of adequate size without the use of a magnifying lens. Its input is provided via a separate coaxial cable from the channel output so that the operator sees the same picture as the viewer, but with the d-c component. Continuously adjustable equalization for different camera cable lengths is provided and, when desired, the operator can introduce an overshoot to facilitate focusing on low-detail scenes.

The kinescope face is set as little as possible into the camera so that it can be seen over a wide angular field, as, for example, when the camera is high on a pedestal. Further help in such situations is provided by an adjustable viewing hood which tilts ± 45° and is fully counterbalanced so that it follows the operator's movements up or down. Alternatively a simple light shield is available.

At all times the operator can see above the viewfinder picture an illuminated number, which shows which of the four lens positions is in use, and two red On-Air tally lights, all adjustable in brightness.

Other Camera Features

An electromagnetic orbiting system is driven by a clock motor so that the orbiting in two or more cameras can be synchronized when they cooperate on matte shots. Alternatively, an extra kit will offset the orbit motion.

A large red On-Air tally light on top of the camera also displays the camera number and a small On-Air tally indicates the taking lens. Remote indication can be had of the lens in use and also a Non-Available tally when the turret is off normal. The video signal can also be cut automatically during turret operation.

For voice communication, all sources are amplified to between + 15 dbm and + 20 dbm and individual volume controls are provided at each utilization point for each source, so that the user can adjust both level and balance. Split earpiece working and high impedance is used. Generally, personnel hear the director with one ear and the program sound together with the appropriate engineering circuit with the other. The camera operator can plug in a boom headset or he can mount the microphone on the viewfinder hood. Spare outlets are provided for other personnel at the camera. The channel includes transistor amplifiers for the camera and vision operators' microphones.

The camera cable is all polyethylene insulation and the connectors are moulded on to it also in polyethylene. This special technique, developed by British Insulated Callender's Cables, has been used extensively for about ten years during which time the couplers have been made smaller, to the present 1¾-in. diameter, with a quick release but watertight coupling. Demountable couplers are also available for use with this cable which is only 1⅛-in. diameter. The small size comes mainly from the high insulation of the polyethylene for the cable which contains three 75-ohm coaxial cables, three screened quads and 18 other conductors, in all, seven more conductors than contained in the usual American cable, making it possible to put circuits and controls in the camera control rather than in the camera. As the coaxial and quad screens are separated from the main cable screen they can also be used for more or less grounded circuits, so that up to 11 extra circuits are available.

Cable entry is towards the bottom of the middle of the operator's left side, where it makes the minimum movement during panning and tilting, and is the least nuisance on cranes and for low shots. A right-angle cable connector is also available bringing the cable back along the camera; it can then work even on the floor or on a bench. An intermediate tag board between the camera connector and the camera wiring provides easy maintenance checking and simplifies replacing the camera connector if it gets damaged. Normally up to 1000 ft of camera cable can be used, but the design envisages up to 2000 ft if required.

The preferred method of mounting the camera uses a V-wedge on the camera sliding into a V-slot on the pan-and-tilt head, but provision is also made for using both the large and small Mitchell single bolt fixings. To offset unbalance from heavy lenses, prompt devices, etc., the camera can be moved relative to the mounting point while on the head.

Carrying handles fix into bosses at the front top and bottom of the camera and also the back. These bosses are also used to attach prompt devices, eyelights, etc. At the back a script board can be arranged for the cameraman.

Channel Packaging

The remainder of the camera channel contains the four units:

(*a*) power supply,
(*b*) camera control,
(*c*) control panel, and
(*d*) picture and waveform monitor.

The first two of these units are each housed in a "printed wiring box." Figure 3 shows the camera control box. All the electronic circuitry is divided into a number of plug-in printed wiring boards[7] which have tubes and components on one side and the wiring on the other. This is good for maintenance but uses a relatively large area, so the printed wiring box was developed. This consists of a box frame, open top and bottom, from which withdraws very easily a vertical panel carrying with it the front panel. Printed boards plug onto both sides of the vertical panel. The back of the box is a connector panel with the connectors tilted downwards to reduce the depth required. Also heavy and reliable items such as a mains transformer are

mounted on the back panel to reduce the weight on the runners. Wiring between the connectors and the sliding member forms a simple gravity-controlled loop within the box when it is closed. The connecting cables do not, of course, move.

Dimensions are chosen so that two boxes mount side by side across 19-in. racking and occupy 15¾ in. of rack height. Air circulates up the four chimneys thus formed and can be forced through several boxes placed one above the other or on a ventilating shelf (Fig. 3). Air is ducted from the front, through the boxes, and discharged up the cabinet sides due to the next shelf above.

Exploiting cabinet depth in this way, more circuitry can be accommodated, in printed form, than by using conventional construction. Virtually four mounting surfaces are provided up the cabinet. Excellent access is provided to all items from the front only.

These cases are also available fitted with a plug system at the back. The plug system engages with sockets on a frame so that the entire unit can be replaced with a spare in a single operation.

For remote use, the same case is simply fitted with a ventilated top and bottom; the latter includes skids and fits a shock mounting tray.

The power supply provides the usual supplies, all fully regulated but with an overall efficiency of 65% for the B+. The dissipation is in fact reduced to 150 w compared with 430 w for a conventional supply of the same rating. It is achieved by using a transductor for relatively slow regulation and a single 6080 high-speed regulator operating in class B.[3] Performance is at least equal to that of conventional supplies in all respects, the most important of which is the low source impedance. The power supply occupies only about half of the printed wiring box and in the remainder is contained the servo magnetic amplifier for the remote iris and a small board carrying the two transistor amplifiers for communication. The camera cable also terminates on this unit, again on an intermediate tag board.

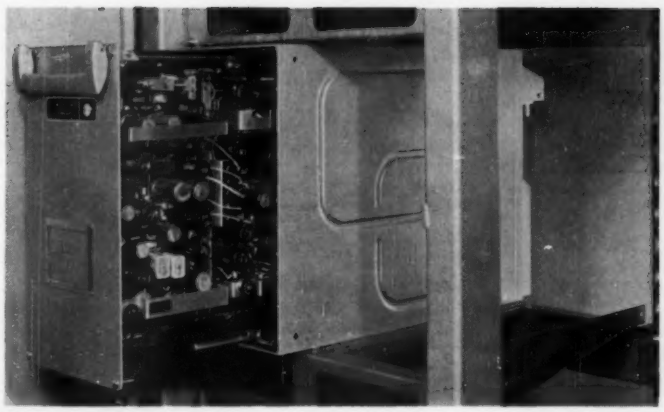

Fig. 3. Printed wiring box in rack on ventilating shelf, partially open.

Facilities

The general channel facilities can perhaps be best outlined by reference to the control panel (Fig. 4), since every effort has been made to concentrate all controls and presets on this entirely passive panel, including those normally located in the camera or elsewhere. Mechanically the panel is 14-in. by 8-in., and the legend is on edge-illuminated Lucite. A flap cover divides the panel into operating and preset sections.

In the main operating section, large knobs are provided for the main operating control *Iris*, and also for *Lift* and *Gain* which may require slight adjustment on scenes of very high or low contrast range. The *Black Stretch* controls are located so as to be at the operator's right. Their use as operational controls is still a matter of debate but will be worked out in the next year or so. The case for operational control is that not only should the tube be correctly exposed for the highlights, but the gamma should be adjusted according to the scene contrast so that, for example, a high contrast scene uses a lower gamma to fit it into the limited contrast range of the broadcast system, including the viewers' receiver and viewing conditions. In the studio, at least,

Fig. 4. Control panel.

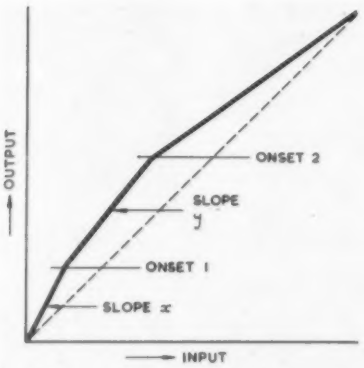

Fig. 5. Electrical transfer characteristic with black stretch.

control of staging and lighting can avoid large changes of scene contrast.

The input/output transfer characteristic is divided into three slopes (Fig. 5). The *Black Stretch Onset* controls 1 and 2 adjust the position of the "breaks." In practice, the transitions between the slopes is gradual so that a continuous curve results. The slopes x and y are controlled by two resistors plugging into the camera control and can be selected as required. The slope gain of the lowest part of the curve can be up to 16 db relative to the average slope. The switch *Black Stretch* removes any stretch in the *Off* position. As an extra facility, positions 1, 2 and 3 control a Ledex (remote actuator) in the camera control which switches in three different sets of x and y slopes, otherwise the fixed slopes are introduced in all three positions. The *Rem* (remote) position switches control of *Gain*, *Lift*, *Iris* and the black stretch controls to a remote panel.

Associated with the *Iris* control is a tally lamp labelled *Iris Motor* showing when it is running and the *Set Limits* presets the calibration of the control with the lenses. *Panel Lamps* is a dimmer on the panel lighting system. *Uncap* electronically caps the camera in the unoperated position by disabling the image section, and *Overscan* increases the target area scanned during rehearsal, the amount being preset by *H Overscan* and *V Overscan*. Both these help to avoid "burning" the tube. *Mix Viewfinder* mixes with the normal feed to the viewfinder another picture fed into the camera control. It helps the cameraman to set up on superimposition or matte shots.

On the left of the operating section are the interphone volume and other controls. The *Mains On* switch removes all power from the camera and also B+ from the camera control unit, etc., but leaves the tube heaters on there. The channel is switched off completely on the power supply.

In the preset section are the usual tube electrode controls; many have coarse and fine controls for precise operation.

Fig. 6. Console with picture and waveform monitor and control panel.

"Foolproof" alignment is provided by *Auto Align;* the switch introduces modulation of the beam focus with a square wave at frame rate. Then the Cartesian X and Y controls are adjusted to eliminate the double image produced. This is particularly easy if a test chart including crossed diagonals is used. Then the X control fuses one diagonal split image and the Y control fuses the other. Scan reversal switches have associated separate centering controls for normal and reversed so that immediate reversal can be used. Picture polarity reversal is on a switch in the camera. A *Beam* switch allows the beam to be cut off if required without disturbing the control setting, and a *Set Target* switch makes it easy to adjust the target to a standard value above cutoff. Focus modulation is provided for use on 3-in. tubes without a field mesh.

An operator at this panel can set up for a new tube or check the performance of an installed tube without needing the cooperation of a camera operator. The switch *Test W/F* controls relays which switch the viewfinder coaxial so that it takes any test signal patched into the camera control and injects it into the camera head amplifier input, retaining the normal strays. At the same time, it removes any injected shading waveforms, without having to disturb the control settings, and immobilizes the image orthicon by removing the major tube potentials and scanning. Thus, the overall channel electrical performance can be very quickly checked.

For image-orthicon adjustment, a diascope replaces any lens and automatically picks up a lamp supply from the turret. Its illumination is controlled from the panel by the *Iris* control. A precision 2 by 2-in. dual slide holder carries a suitable test chart. The operator can then set up the control panel using the correct exposure. He can "cap" the camera when not actually working with it.

Picture and Waveform Monitor

Precise operation is considerably helped by the Mark IV Picture and Waveform Monitor which has a 14-in. electrostatic, rectangular picture tube of high brightness with small spot size, and excellent uniformity of focus. This relatively large size makes for much more accurate adjustment and checking of most parameters, and it is associated with a bright and well-focused 5-in. waveform monitor using 3 in. of Y deflection. The monitor has several important features for camera control purposes:

(1) line selection to show resolution response or gray scale from a test chart, and to indicate signal-to-noise ratio, shading, etc.,

(2) ring main calibration through all monitors in a system,

(3) superimposition of grating for positional error checking,

(4) second input for comparison with On-Air picture, etc., and

(5) X deflection rates to also show lines, fields, sync and blanking periods with 1-μsec calibrate "pips" for line pulse checking.

Like other Mark IV equipment the picture and waveform monitor uses plug-in printed wiring boards and includes a transductor regulated power supply.

It mounts in a console with the control panel in the desk section, and for main-

tenance a tray draws out from under it. When a catch is released, it rolls easily up this tray, assisted by a constant tension spring counterbalance (Fig. 6).

For remote use, the monitor on its extensible tray fits into a carrying case and the control panel into a separate housing mounted below it.

Electrical Performance

The designer of a 4½-in. camera, presented with a camera tube of superior performance, must engineer the camera channel to standards worthy of it. The economic realities are that this must be achieved with little cost increase. This presents an exciting challenge to the circuit designer. After producing a focusing and deflection system with suitably low image section crosstalk, good landing and focus conditions and reduced positional errors, he must then devise a signal processing chain which has virtually immaculate amplitude and phase performance with provisions for offsetting tube deficiencies by adjustable aperture and contrast correction.

This starts right at the head amplifier which uses a low noise cascode input. Feedback is used to reduce the input impedance so that only a small and fixed amount of high peaking is required. In signal processing, a continuously variable cable length equalizer is followed by a greatly simplified phaseless aperture corrector, dispensing with the conventional artificial line and having only one variable potentiometer but retaining constant low-frequency gain.[9]

Blanking is added and clipped in a stage controlled by a feedback clamp and the signal is black-stretched. A peak white limiter prevents inadvertent overloading of subsequent facilities and a fixed pedestal can be added.

The problem of clamp pulse timing is neatly taken care of by taking it from a pulse coming from the camera so that it always has the optimum relationship to the video signal, irrespective of the length of camera cable used. This allows the benefit of a relatively wide clamp pulse.

Operating Technique and Stability

Detailed tests by the British Broadcasting Corp. on the Mark III camera channel showed that, with a little improvement, it is possible to set up a 4½-in. camera channel and then leave it alone apart from, say, daily checks. Thereafter video operating consists of setting the *Exposure* with *Lift*, *Gain* and perhaps *Black Stretch* as subsidiary operating controls. This method yields far better results than results achieved by the confirmed and often inexpert knob twiddler. Even an expert finds it almost impossible to set up a channel correctly on an unknown and changing scene, and optimum settings are easily lost.

Some time ago, Columbia Broadcasting System also realized, independently, the possibility and advantages of such a method of operation. The Mark IV can be used in conventional fashion, but an important design aim of the channel is to make it sufficiently stable so that access to only the controls in the operating section of the panel is required, apart perhaps from a daily check. This can be done with the conventional arrangement, closing down the preset control covers; but it suggests, particularly for large installations, an alternative where the control panels are housed with limited monitor facilities, perhaps in a general apparatus room. Four panels for instance can be located with a single picture and waveform monitor in only two consoles. Then a remote control panel carries the operating controls for all channels, together with communication facilities as required.

The location of this central control panel with its operator is still subject to operational evaluation.

Now that the more technical side of video operation has become a matter of routine maintenance, video operating can be considered to require artistic rather than technical abilities. The best operator will be the one who can recognize the required picture, in the photographic sense, and obtains it by suitable exposure and occasional use of the *Black Stretch* controls and *Lift* and *Gain;* corresponding to choice of printing exposure and printing paper grade.

To achieve this "hands off" operation, the designer has to pay the greatest attention to stability in the camera channel. After a brief warming-up period, all image-orthicon electrode potentials must be stable as well as the scan amplitudes, centering, and all the subsequent signal processing. They must also be stable against changes of line voltage, ambient temperature, and pulse variations. In the Mark IV, the required stability has been met by the application of straightforward engineering practices. Design factors that contribute include input pulse stabilization, thermostatic control, supply regulation including the dynode supply, feedback clamp, use of silicon diodes, high stability resistors and Mylar capacitors, and the use wherever possible of 6922/E88CC tubes. The latter is a double triode for professional use. It has high performance with closely controlled parameters and long life. It is used with d-c stabilization to further reduce the effect of tube variations. Sixty-five per cent of the tubes are of this type and the others are chosen within a restricted variety of the best available types.

Staging and Lighting

Since the operational sensitivity of the 4½-in. tube is very much the same as the 3-in. tube, its introduction does not require any change of lighting load. It is interesting to note that European practice tends towards a smaller depth of focus than is common in America. Image orthicons in studios are generally used at about $f/5.6$ with a considerable saving in lighting and ventilation.

As regards contrast range, the CBS *Rules for Staging and Lighting*[10] laid down ten years ago, are still very relevant in spite of their author's reservation "they are subject to early obsolescence in such a rapidly changing art as television." The 4½-in. tube will give excellent pictures from scenes of both higher and lower contrasts than specified, but this really implies the use of black stretch as an operational control to fit them into the limited contrast range of the subsequent system.

An important difference between 3-in. and 4½-in. image orthicons is the visibility of redistribution effects. If a woman's face is lit with plenty of soft fill-light then on the 4½-in. it will look like a studio portrait; but on the 3-in. due to the strong redistribution each skin imperfection and the age lines will be accentuated and she will look 10 to 20 years older. Unfortunately, this usually leads to the charge that the 4½-in. tube gives a "soft" effect compared with the 3-in.; true, but it is so much kinder to the human face. With a 4½-in., when a "hard" picture is required then the lighting must be hard. For it more nearly shows what it sees. To get a really crisp picture it should look crisp on the set, requiring small area sources and an increase of contrast range to 50:1 or more.

Generally, viewers seem to like what they are used to. So that in changing over from 3-in. to 4½-in. image orthicons there is usually a certain amount of customer resistance to the lack of spurious redistribution effects and in this period it seems advisable to use relatively hard lighting and to produce a contrasty picture by omitting black stretch. More subtle effects can come later. Sound broadcasters had the same problem in going from a nice "mellow" tone to Hi-Fi. Also, operators used to the 3-in. tube often show a tendency to overexpose the 4½-in. tube making it look more like a 3-in. tube, but this should be resisted.

Exposure control can reduce the need for careful balance of brightness between sets and even across a set, but this puts more load on the vision operator.

The lighting artistry is very much controlled by the time and money available to set the lighting and the choice and ability of the personnel.

The 4½-in. tube responds quite well to scenes ranging from flat high-key lighting down to deep limbo shots.

While the 4½-in. tube most nearly approaches the ideal camera tube at

this time and therefore removes many restrictions, it can not make an artistic picture from a scene badly staged or lighted. Staging and Lighting are as essential to the production of a high-quality picture as engineering, but the 4½-in. tube can make the most of artistic staging and lighting, unlike the 3-in. tube which, conventionally operated, tends to make all pictures look alike.

Acknowledgments

The author wishes to thank B. N. MacLarty, the Engineer-in-Chief of Marconi's Wireless Telegraph Co., Ltd., for permission to present this paper.

The work outlined represents the creative efforts of very many people in both the image-orthicon and equipment development fields. In particular our thanks are due to the early encouragement of L. H. Bedford and to G. B. Banks, W. E. Turk and E. Hendry of the English Electric Valve Company, for the tube work, and to E. Davies, B. M. Poole, G. King, R. H. Oddy, E. O. Holland, A. N. Heightman, G. L. Cooper, C. F. H. Teed, W. T. Underhill, R. S. Cox and D. P. Parkinson of Marconi's Wireless Telegraph Co. for the camera channel design.

Valuable guidance has been provided by innumerable discussions and suggestions from television people all over the world, and we wish particularly to acknowledge the contributions made by D. C. Brothers and A. B. Palmer of BBC.

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A Transport Mechanism Design for the Television-Tape Recorder

By JOSEPH G. LEE

The major units of a television-tape transport mechanism are described; their basic functions and relations to the complete system are set forth. Photographic and graphic illustrations of the design are presented.

THE POTENTIAL of the television-tape recorder in the development of the television industry is ever expanding. Its use in television programing is just beginning.

Although the equipment is largely electronic, the very heart of the machine, the tape transport panel, presents many mechanical problems. The handling of the tape from supply reel over the recording heads and onto the take-up reel is mechanical in nature.

This function requires a transport assembly to convey the 2-in.-wide tape over the necessary recording and pickup heads, while maintaining correct speed and tension to give the required performance. At the same time the equipment must record the audio, video and control signals in accordance with SMPTE standards.

Operation of the Transport

The transport mechanism for the TRT-1A television-tape recorder, shown in Fig. 1, in addition to meeting the basic requirements, includes many new design features. It is the center panel of a three-rack unit. The control panel is on the right; the picture monitor is on the left.

In Fig. 2 the upper reel is the supply from which the tape to be played or recorded is paid off. The lower reel is for storage of the tape. The tape passes from the supply reel under the upper tension arm post, the purpose of which is to take up excess tape in the event of erratic motion.

Preceding and following the master erase head are two air guides which position the tape for its approach to the head wheel. During recording, the master erase head erases any previously recorded signals. Video and control signals are either recorded onto or read from the tape by the head-wheel assembly.

After leaving the head-wheel assembly the tape passes over the erase, audio and cue, and simultaneous monitoring heads. The third air guide changes the direction of the tape for its approach to the capstan and the pinch rollers. When playing or recording, the pinch rollers clamp the tape against the capstan, which controls the tape speed.

The counting capstan and lower tension arm post are the last two units the tape passes over before going to the take-up reel. The counting capstan is rotated by the tape and thus counts the length played or recorded.

The structural support for the transport consists of a cast aluminum plate, precision ground on both sides to a thickness of ½ in. Along each edge it is fastened to a 2 by 3-in. extruded aluminum angle. The angles are in turn fastened to the rack frame. All assemblies and components, except the air guides and master erase head, are fastened to the aluminum plate, using tapped holes.

Reel Motor and Brake Assembly

The reel motor, hub and brake assemblies are key units in the handling of the tape. The motor supplies the power to hold back or take up the tape; the hub assembly supports the reel and tape; and the brake operates to bring the reels to a safe stop.

The reel motors are of induction torque design, with a rating of 65 in-oz at 75 v. The front flange of the motor is used to fasten it to the mounting plate. The brake assembly is mounted on the rear flange. The complete assembly of motor, hub and brake can be easily removed from the transport for service or repair.

During rewind the upper motor is fully energized and starts at a maximum speed of 875 rpm and decreases as the reel fills. During maximum speed rewind the lower motor is energized to rotate counterclockwise with approximately 50 v. However, its direction of rotation is clockwise and its speed is determined by the tape speed, which increases with the radius of the upper reel. In the play condition the motors operate at a constant

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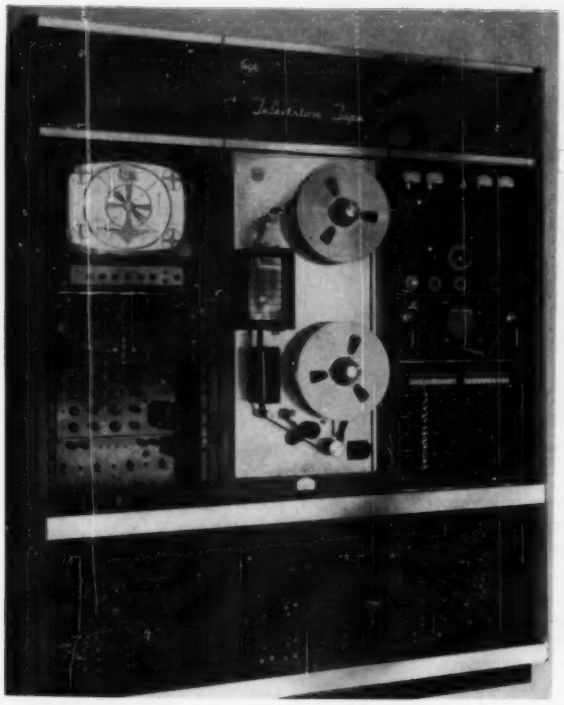

Fig. 1. TRT-1A/1AC Television Tape Recorder.

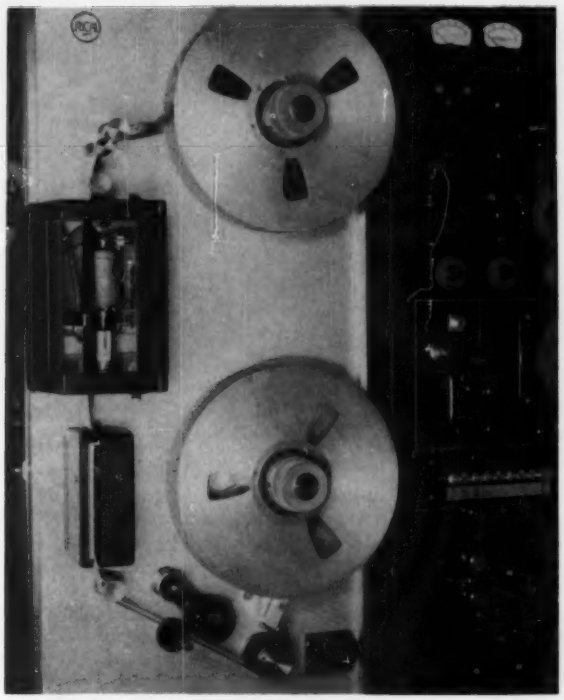

Fig. 2. TRT-1A/1AC transport mechanism.

torque. The supply motor operates at slightly below 5 in-oz, the take-up motor at 10 in-oz.

The reel hub assemblies support the reels and hold them securely to the motor shafts by a unique design. As can be seen in Fig. 3, there are three pawls that clamp the reel against the flange of the hub. The hub is secured to the motor shaft and has three equally spaced slots in which the three pawls ride. The actuation of the pawls starts with the rotation of the knob. The knob is fastened to and rotates with the screw which is restrained from moving along the shaft. Thus when the screw rotates, the nut moves in or out, carrying the actuator with it. The actuator is linked to the pawls with three pins running through the elongated hole in each pawl.

The operation of the reel hub assembly is as follows: Turning the knob counterclockwise causes the nut and actuator to move toward the knob. The pawl first moves toward the knob, thus relieving the pawl spring. When the rear edge of the captivating hole is resting against the retaining pin, the finger end of the pawl moves down. With the pawls in this position the reel is free to be removed. The clockwise rotation of the knob causes the pawls to move first up and then in, thus clamping the reel.

The brakes are fail-safe since they are spring actuated and solenoid released. The braking is done by an asbestos-lined band on a brass drum. The linkage is arranged to give differential braking on approximately 240° of the drum. Differential braking is required to keep the tape tight during stops from high-speed wind and rewind.

Head-Wheel Panel Assembly

The transverse recording of the video signals is performed by the head-wheel panel assembly (Fig. 4). The principal parts of this assembly are motor, head wheel, slip rings and brushes, tone wheel and shoe. The motor is a three-phase, hysteresis synchronous type running at a nominal speed of 14,400 rpm. It is surrounded by a shroud which serves as a magnetic shield and a duct for cooling air. The cooling air is drawn in at the head wheel and exhausted through the mounting plate to the low-pressure vacuum pump. The head wheel is a nonmagnetic wheel of 2.0642-in. diameter with four equally spaced magnetic pickup heads mounted in it. The poles of these heads protrude approximately 0.004 in.

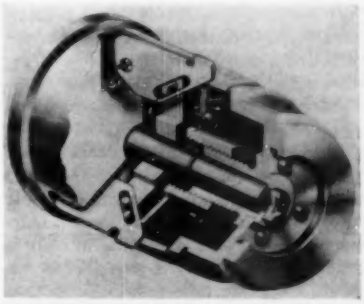

Fig. 3. Cutaway of reel hub assembly.

The head-wheel and motor assemblies are the most precise parts of the equipment. To ensure complete interchangeability, that is, the ability to play any tape recorded on other machines, quadrature of the heads in the wheel is set to within

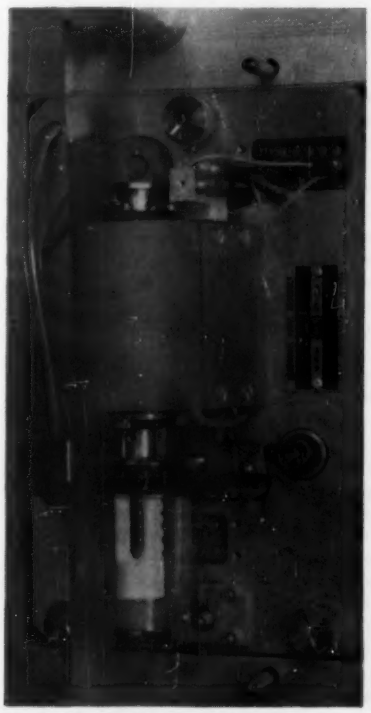

Fig. 4. Head-wheel panel assembly.

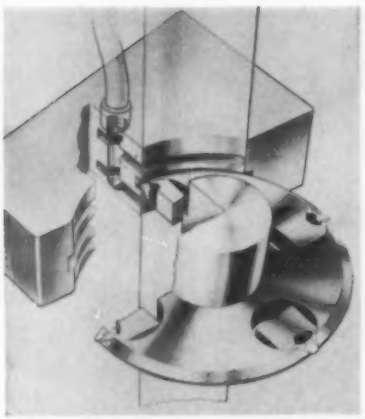

Fig. 5. Cutaway of head wheel and shoe.

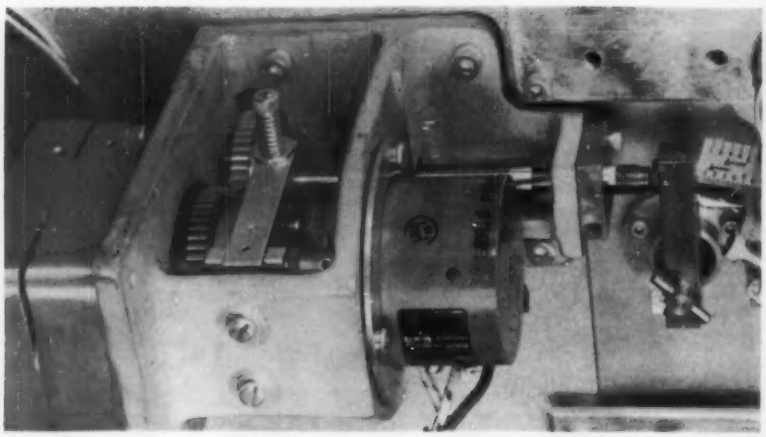

Fig. 6. Shoe servo drive mechanism.

±15′ of 90°. This represents the achievable precision at the present. This is equivalent to ±0.05 μsec of time with the wheel rotating at 240 rps. In addition, electrical delay line adjustments are provided so that the final head-wheel quadrature accuracy is ±0.01 μsec.

Peripheral speed change causes a lateral shift of an element in the video picture that is called jitter. The maximum permissible jitter is ±2 μsec. The stability required is better appreciated by considering that one revolution of the head wheel is 4167 μsec. Mechanical items contributing to jitter are bearings and balance.

The two ball bearings used in the motor are ABEC Class 7 selected for less than 50-μin. eccentricity and for low noise. The low-noise requirement necessitates a very fine finish on the balls and races.

After the rotor, head wheel, and slip rings are completely assembled into a stator housing, the head wheel is balanced not to exceed a limit of 50 μin-oz.

The tone wheel and pickup head are at the top end of the motor. The tone wheel is mounted on the motor shaft and consists of a soft-iron disc with a notch in the periphery. The notch in the tone wheel interrupts the flux path of the pickup on each revolution. This interruption induces a 240-cycles/sec pulse that is compared against a reference. Thus an error signal is obtained to control the head-wheel motor speed.

The shoe is a solid block of nonmagnetic material that has an inner radius of 1.0329 in. (Fig. 5). It has three slots cut into it. The center one is for the pole-piece protrusion. The two outside slots have a vacuum of 5 in. of mercury applied to them to hold the tape against the shoe and thus stabilize it. The shoe is mounted on an arm which is pivoted near the top of the head-wheel panel.

The shoe and its position are a common source of imperfections seen by home viewers. The imperfections appear as jogs or offsets every sixteen or seventeen TV lines. The offset jogs are the most common of several possible picture defects caused by incorrect shoe position.

The jogs are caused by improper stretching of the tape as the protruding pole tips pass across it. Protrusion beyond the radius of the shoe is necessary to assure good contact with the tape. The amount of protrusion is commonly referred to as shoe pressure. Too little pressure will cause jogs sloping to the right until loss of signal occurs. Too much pressure will produce jogs sloping to the left. The movement of 0.001 in. will produce a jog of $\frac{1}{4}$ in. on a 17-in. monitor.

In order to adjust the shoe pressure and open the shoe for tape loading, the shoe arm pivots and swings out in plane with the head-wheel panel (Figure 4). The movement of the shoe is determined by an eccentric bearing located on the shoe-position shaft. The shoe arm is spring-loaded against the shoe-position bearing as well as perpendicular to the head-wheel panel against adjustable pads. By adjusting these pads the shoe can be made concentric with the head wheel. To move the shoe from its open position to zero contact with the tape, the shoe-position shaft rotates until the positioning arm attached to it comes to rest against a motor-driven lead screw (Fig. 6). The shoe-position shaft is rotated by a rotary solenoid (removed in Fig. 6). The shoe-position motor is operated either manually by a potentiometer on the control panel or automatically by a servo unit that is fed a jog error signal.

After the tape leaves the head wheel and shoe, the inside edge passes over the control-track magnetic head. It is located $\frac{3}{4}$ in. below the centerline of the head wheel. Its purpose is to record 240-cycle control-track signals during record. During play it supplies the signal to control the capstan servo. In this way the capstan motor keeps the tape positioned so that the head wheel is reading a single track.

Capstan, Pinch Roller and Linkage

The capstan motor controls the tape speed. Its shaft is sized to give a tape speed of 15 in./sec at a speed of 600 rpm. It is a hysteresis synchronous two-phase motor with a rated running torque of 11 in-oz. To smooth out speed fluctuations, a flywheel is mounted on the other end of the capstan motor shaft.

The pinch-roller assembly is a self-aligning split roller design utilizing the controlled looseness of ball bearings (Fig. 7). There is sufficient freedom of the shaft in the arm and of each roller on the shaft to allow the rollers to align with the capstan shaft. The actuation of the pinch rollers is done by a rotary solenoid

Fig. 7. Capstan motor, pinch roller and linkage.

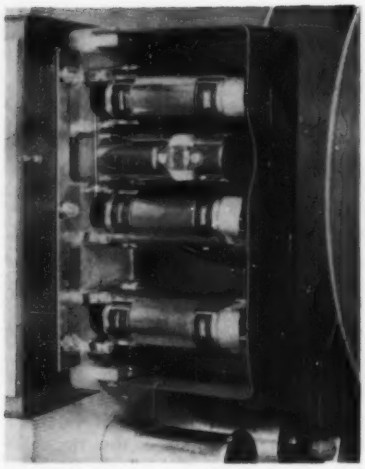

Fig. 8. Audio head supports.

through a spring-loaded link. The spring-loaded link provides more clearance between the pinch roller and the capstan by not using the solenoid stroke in compressing the pinch-roller spring up to the minimum load point. This allows the first 30° of the solenoid rotation for moving the pinch roller down to the contact point; the remaining 15° compresses the spring and the pinch rollers. The knuckle action of the solenoid arm and the spring-loaded link reduces the holding torque required of the solenoid.

Counting Capstan and Counter

To count the linear footage of tape, a counting capstan, whose circumference is 6 in., is used. It is geared to the counter through a small drive shaft parallel to the panel. Between the capstan shaft and the driveshaft is a 20:1 pair of worm gears. On the end of the driveshaft is a spur gear driving a matching gear on the counter shaft. The counter is a conventional four-digit counter, which adds, subtracts and records ten digits for each revolution, thus providing direct reading of footage.

Audio Heads and Mounts

After the video and control-track signals are recorded it is necessary to erase the excess video for audio and cue tracks. This is accomplished by two erase heads mounted in the first support (Fig. 8). The second support holds the cue and program audio heads. However, between the first and second support there is a back post which makes it possible to obtain the proper wrap on each support, yet allows the three supports to be in a straight line. The two heads in the third support provide simultaneous playback of program audio and control-track signals. All six heads are adjustable for track location. In addition to track location the program audio and simultaneous program audio are adjustable for azimuth.

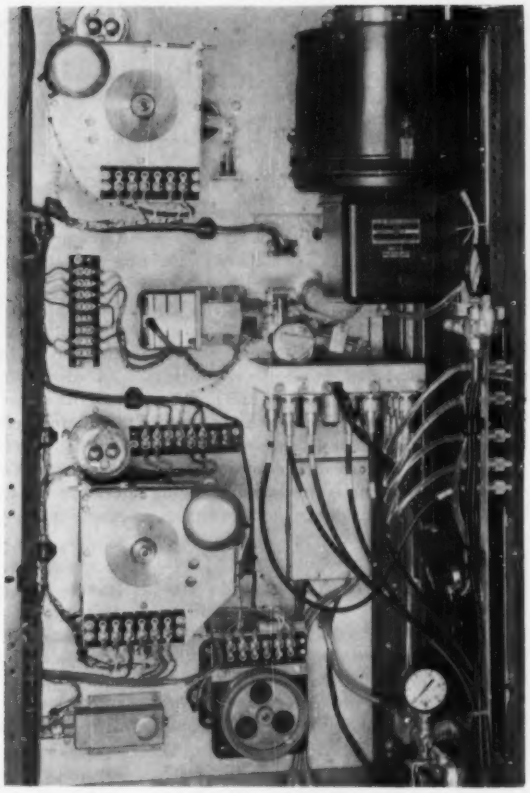

Fig. 9. Rear view of transport mechanism.

Tension Control

In the record and play conditions the reel motors are energized to give a fixed torque, regardless of the amount of tape on either reel. The tension of the tape changes because the radius of the reel changes from a minimum of 2.25 to 6.75 in. for a 14-in. diameter reel. This three-to-one change in tension causes the load on the capstan to change from holding back at the start of a reel to pulling at the end of the reel. In terms of load on the capstan, a representative change would be from −3 to +2 in-oz from the start to the end of a 7200-ft reel.

The tension arms on this machine serve their normal function of taking up or paying out tape at a faster rate than can be provided by the reel. Unilateral viscous damping has been provided to operate when paying out tape on both upper and lower tension arms. This is accomplished with unidirectional air dampers. These are mounted on the rear of the support panel. Damping in this manner stabilizes the tape speed more quickly in starting.

Styling

In rack-mounted equipment it is often not possible to discern where one equipment ends and another begins. In the TRT-1A the three racks have been brought together by both decorative and utilitarian trim. The two horizontal guard rails across the lower front protect the transport assembly. The doors and their horizontal trim strips give it the appearance of a single unit. The transport area was designed to have a clean, uncluttered appearance, contrasting with the dark units on either side which have many controls and tubes.

The transport support panel is covered with an aluminum overlay. It has an etched wavy-line pattern, with borders around all components and edges. The overlay and trim bars have a brushed satin finish. The machined parts are satin chromium finished. The covers for the head wheel, audio supports and counter are finished a dark umber gray vinyl.

In addition to giving the best in performance, this tape transport was designed to be accessible for easy service, operation and maintenance (Fig. 9). To that end every major unit can be serviced without disturbing or removing any other unit. The reel motor assemblies, capstan motor, shoe servo, preamplifiers and head-wheel blower are all easily removed for service or repair. The head-wheel cover offers good visibility, is easily opened for threading and service and is readily removed.

A Simplified Method of Conversion of Standard Intermittent Motion-Picture Projectors for Use With Television Pickup Tubes

By J. S. CHANDLER

A 35mm Simplex projection head was converted for use as a television projector with the 3:2 field-sequence method of utilizing film taken at the rate of 24 frames/sec for the 30-frames/sec television standard. A 35% application time is obtainable with a 5-in.-diameter shutter blade running at 3600 rpm. The entire mechanism, including the feed and holdback sprockets, shutter and intermittent Geneva, is driven from a single 1800-rpm synchronous motor. A timing belt drive is used for the intermittent mechanism. An eccentric toothed idler pulley of twice the diameter of the Geneva drive pulley is interposed between the motor and the Geneva drive to produce the required advance and retard modification of the rotary motion. The timing and change of acceleration are illustrated by curves. This method of conversion offers the advantages of simplicity and economy. Very little added noise or acceleration loading is produced and long operating life may be expected.

NUMEROUS METHODS have been employed to project motion-picture films taken at the standard 24-frames/sec rate into television systems based on the standard 30-frames/sec rate. If intermittent projectors are used, some type of storage tube such as the vidicon is employed as the pickup element to allow a portion of each television field to be blanked out by a shutter blade. It is generally accepted that if the light application time is at least 30% of each television field (of 1/60-sec duration), the resulting picture quality from the storage pickup tube is entirely adequate.

Various arrangements of shutter and pulldown timing have been used successfully. For some 16mm equipment with film-advance mechanisms utilizing less than 50° of shaft rotation (related to a shaft rotating at a uniform rate of 24 turns/sec) for each frame of film, the 30% application time can be achieved by the use of two shutter interruptions per field (120/sec) and a uniform pulldown rate of 24/sec or once for every $2\frac{1}{2}$ television fields.

For 35mm equipment, however, the usual Geneva advance mechanism requires 90° of driveshaft rotation for each frame advance. Faster rates require special drive arrangements and would result in undesirably high acceleration forces, noise, wear and vibration. Accordingly, the 3:2 scheme of advance timing is usually resorted to. By this arrangement each frame of film advance is initiated at alternate intervals of time corresponding to three and two television fields, that is, at alternate time intervals of 1/20 sec and 1/30 sec or a total time of 1/12 sec for each two consecutive frames, giving an average rate of 24/sec as it should.

If the Geneva driveshaft is rotating at essentially the constant rate of 24 turns/sec during the 90° of each advance movement, then the advance time is 1/96 sec for one frame and a maximum application time of $37\frac{1}{2}$% results, assuming a shutter efficiency of 100% and no phasing tolerance. In the mechanism to be described, the advance time has been reduced 5%, resulting in a maximum application of 40.7%. Some equipment using the 3:2 sequence plan utilizes a driveshaft for the Geneva running at a constant rate of 30 turns/sec.[1] The timing is controlled by the correct sequence of insertion or withdrawal of the two star engaging pins provided in this special Geneva mechanism. By this means the advance takes place in 1/120 sec for each frame, and a maximum application time of 50% results. The higher drive speed, however, results in a 56% increase in acceleration.

The Use of a Timing Belt and Eccentric Idler to Obtain 3:2 Timing

By referring to the schematic sketch (Fig. 1) we see that the timing belt *A*, which has molded teeth (with a pitch of 3/8 in.), is threaded over the motor grooved pulley *B* which has 12 teeth, the smooth idler *C*, the eccentric idler *D* which has 30 teeth, the Geneva drive pulley *E* which has 15 teeth, the smooth, floating idler *F*, and the sprocket-drive pulley *G* which has 15 teeth. The pulley *B* is mounted on the shaft of an 1800-rpm synchronous motor. This causes the idler *D* to rotate at the average speed of 12 rps and the Geneva pulley *E* to rotate at the average speed of 24 rps. At the upper- and lowermost extreme positions of idler *D*, as shown by the sketch, the angular velocities of both idler *D* and pulley *E* are equal to the average velocity. For a narrow region before and after the extreme positions, the velocity deviates only a small amount from the average. It is at these two zones of operation that the advance action of the Geneva takes place.

The 3:2 sequence arrangement calls for the film-advance action to take place at alternate time intervals of 1/20 sec and 1/30 sec. This means that the average time interval of 1/24 sec must be altered the amount of plus and minus 1/120 sec. This corresponds to the time for one-fourth revolution of the motor shaft which is rotating at the constant rate of 30 turns/sec. Since there are 12 teeth in the motor pulley, this represents exactly three teeth or three belt pitch lengths. The function of the eccentric roller *D*, therefore, is to feed three additional belt pitch lengths to the Geneva pulley *E* at its extreme lower position as compared to the extreme upper position. This is accomplished by an eccentricity of 9/32 in. Actually the advance action is not centered exactly at the extreme positions of the idler pulley *D* and this skewed relation requires the actual eccentricity to be increased to 0.307 in.

The spring-loaded idler *F* serves to absorb the three-pitch-length variation in belt position set up by the eccentric idler and to establish the correct belt tension. The pulley *G* rotates at the constant rate of 24 turns/sec and drives the projector gear mechanism so as to provide the correct rotation speeds of the supply and take-up sprockets and, if desired, the power take-off for driving the take-up spindle.

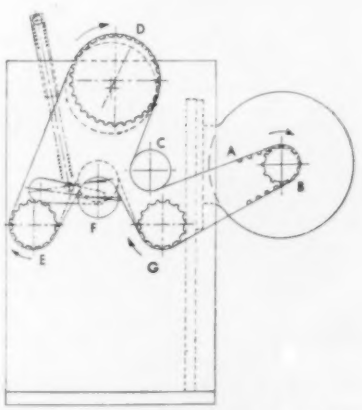

Fig. 1. Schematic diagram of the 3:2 projector-drive attachment.

Communication No. 2058 from the Kodak Research Laboratories, presented on October 8, 1959, at the Society's Convention in New York by J. S. Chandler, Research Laboratories, Eastman Kodak Co., Rochester 4, N.Y.
(This paper was received on October 12, 1959.)

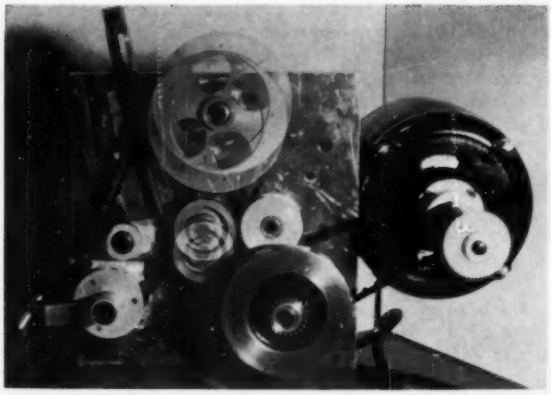

Fig. 2. Double-exposure photograph of belt side of mechanism plate.

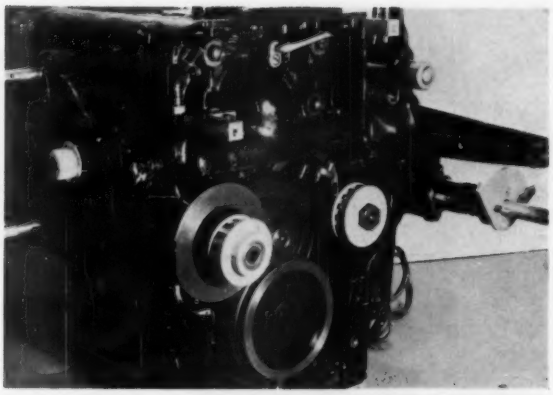

Fig. 3. Photograph of back side of projector head, showing grooved drive pulley on Geneva driveshaft and new location of flywheel and drive gear.

Application to Simplex Projector

Figure 2 shows the inside view of the actual mechanism plate as made up for use with a Simplex theater 35mm projector head. The similarity to the sketch of Fig. 1 is evident. The Geneva drive pulley at lower left is normally mounted on the projector shaft in place of the usual flywheel and gear. For the photograph, it was held by means of a clamp to show its position in the belt drive. By using a double-exposure technique, the two extreme positions of the eccentric pulley and the spring-loaded idler are shown simultaneously. The flywheel and gear which were removed from the Geneva driveshaft have been mounted on a new shaft on the mechanism plate and provided with a 15-tooth grooved pulley. This supplies the power to drive the constant speed supply and take-up sprockets. The gear meshes with the same large central gear but on the left side rather than the right side, as shown by Fig. 3.

No alterations or drilling or tapping of the projector head are necessary. The 3:2 drive attachment is fastened to the head by means of two screws in the base plate and two screws in the side plate at the aluminum brackets shown in Fig. 3. The original shutter blade and shutter shaft were removed prior to attaching the plate.

Figure 4 shows a close-up of the means provided to drive the shutter blade. The 2:1 beveloid nylon gears drive the single-bladed shutter at the rate of 60 rps. The shutter blade swings within a 5-in-diameter circle and provides 35% application time. This gives ample allowance for blade coverage time and for phasing tolerance. A 2:1 Kodak Printing Ektar 90mm, $f/3.8$ lens, also shown in Fig. 4, is used to image the film on the vidicon tube. It was found that some lack of uniformity of speed exists in the motor shaft, owing to the varying nature of the load. Therefore, the large gear was arranged to rotate freely on the motor shaft and is driven through the flexible spring shown. This simple mechanical filter provides a uniform shutter speed, and no shutter bar is visible in the televised image. The correct shutter phase is obtained by adjustment of the setscrew clamping the drive end of the spring to the motor shaft. A separate synchronous motor drive can be provided for the shutter if desired and if provision is made for correct phasings. Figure 3 shows a limit sector attached to the rear extension of the framing control shaft. This prevents the framing knob from being turned more than is needed for one perforation pitch length; thus the phasing tolerance required at the shutter is reduced.

Motor Requirements

A single-phase, 1800-rpm, $\frac{1}{8}$-hp motor with split-phase starting was found to be adequate for the entire drive. A $\frac{1}{12}$-hp, split-phase motor was also tried but it required a short running time to settle down without phase slipping. Undoubtedly, a three-phase motor or a single-phase capacitor-run motor would give more than adequate performance in the same or lower power rating.

Illumination

The illumination consists of a simple lamphouse containing an 8.5-amp, 12-v

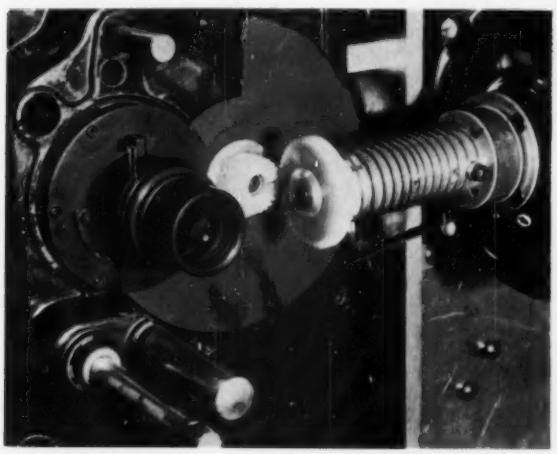

Fig. 4. Photograph of shutter with drive gears and filter spring.

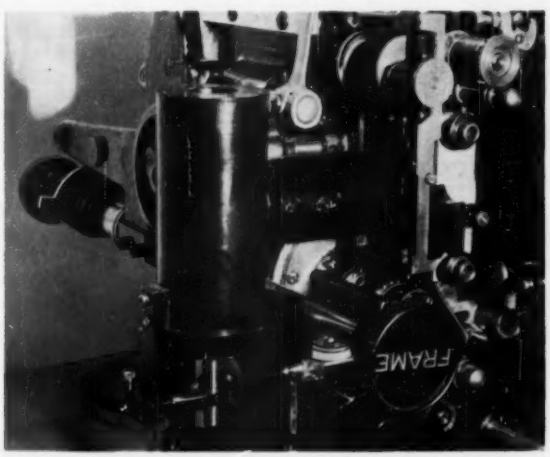

Fig. 5. Photograph of lamphouse and adjustment means.

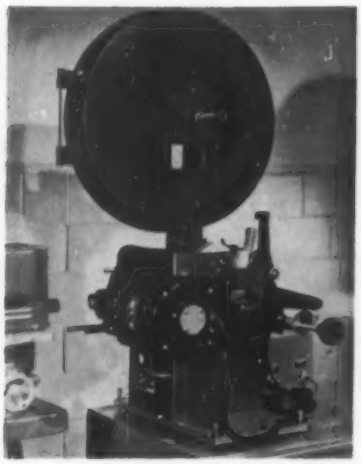

Fig. 6. General view of assembled projector and drive in front of vidicon.

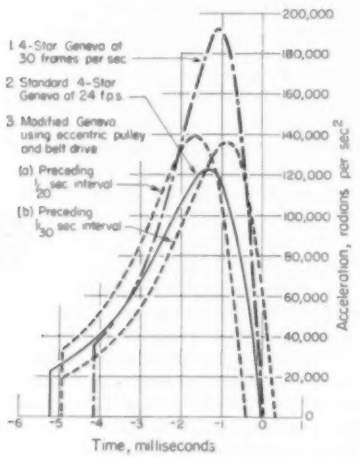

Fig. 7. Acceleration curves of standard and modified Geneva mechanism.

lamp without a blower and with suitable condenser lenses to image the filament into the lens. No safety shutter is used as the film may remain safely in the gate an indefinite length of time. Figure 5 shows this lamphouse and its attachment bracket. Vertical and horizontal lamp-position adjustments are provided. In the television projection tests carried out with black-and-white film, it was found that less than one-half of the rated lamp voltage was required for optimum results. Figure 6 shows a general view of the assembled unit mounted on a suitable table and with a shutter guard in the correct position for operation into the vidicon tube. A well-braced table is required to prevent vibration effects from disturbing the image quality. The performance was found to be entirely satisfactory in all respects.

Any prospective user of this simple, low-cost method of providing a 3:2 projector, starting with standard, generally available projection equipment, is cautioned to examine the patent literature; in particular, a patent in the name of F. J. Bingley[2] dated August 24, 1948.

Acceleration Considerations

The curves of Fig. 7 show the angular acceleration of the various Geneva drive arrangements. In all cases the speed of the drive motor has been assumed to be constant, and, for the eccentric idler modification, the cosine effect of the component of motion of the idler perpendicular to the belt direction has been neglected. Only the positive lobe of acceleration is shown. The negative lobe is symmetrical about the origin with the positive lobe.

The high peak acceleration of the special skip-pin arrangement, using a 4-star Geneva drive running at the rate of 30 frames/sec is clearly shown, as compared to the standard Geneva mechanism running at 24 frames/sec.

It is interesting to note that, for the eccentric idler arrangement, the peak acceleration values are only 17% higher than those for the unmodified Geneva and that the advance time is 5% shorter. This means that we have the equivalent of 85.4° of advance angle rather than the usual 90° of advance angle. This also means that the maximum application time is 40.7% rather than the 37.5% originally assumed. The actual application time, used in the trials with the 5-in. outside-diameter shutter, was 35% with no evidence of travel ghost.

The analysis also shows a skewing action such that the center of one advance motion occurs as the eccentric idler is 9.73° before reaching its uppermost position and the center of the next advance occurs as the idler is 9.73° beyond its lowermost position. This information is useful in adjusting the phasing between the Geneva and the eccentric idler pulleys. Two acceleration curves are necessary to show the complete story (the negative lobe of one cycle is symmetrical with the positive lobe of the next). The analysis also establishes the correct eccentricity at 8.57% of the idler pitch diameter or 0.307 in. for this case.

The acceleration curves and the actual tests indicate that long, trouble-free operation can be expected since only moderate increases in the driving torques are introduced by the eccentric idler drive. The cost of providing such a television projector by the means described is drastically reduced over that requiring special projection heads.

Conclusions

(1) A simple drive mechanism employing an ordinary 1800-rpm motor, a timing belt and an eccentric idler can be made to operate a theater projector in 3:2 timing sequence for television use and to provide a 35% application time.

(2) The single-drive motor also drives the supply and take-up sprockets and the shutter at the correct uniform speeds.

(3) Analysis of the acceleration characteristics shows little change in going to the 3:2 sequence so that life and noise expectancies are comparable to those for theater use.

(4) The cost of providing a 35mm television projector by the means described is drastically reduced as compared to that for a special television projector head.

(5) Operation trials in a closed-circuit TV system have shown entirely satisfactory results.

References

1. W. R. Isom and W. F. Fisher, "35mm intermittent motion picture projector for color TV," *Broadcast News*, pp. 58–63, Oct. 1955.
2. F. J. Bingley, U. S. Patent No. 2,447,839, Aug. 24, 1948. Assigned to Philco Corporation.

A High-Resolution Television System

By L. L. POURCIAU, M. ALTMAN and C. A. WASHBURN

A television system capable of better than 1000 lines horizontal and 700 lines vertical resolution is described. Frame rate is 30 cps, field rate 60 cps with 2:1 interlace. Lines per frame may be varied from 675 to 1035. System bandwidth is 20 mc. The camera employs a standard one-inch vidicon. The equipment was designed for the Department of the Navy, Bureau of Ships.

A PRIME LIMITATION to the application of most closed-circuit television systems of today is the limited resolution they provide. Vertical resolution is limited to about 340 lines by the generally used 525-line standard. Horizontal resolution may be about 600 lines in the center of the picture and about 400 in the corner. Limitation of horizontal resolution at the center is generally due to bandwidth or camera tube or both; while that in the corners is due to deflection defocusing in the camera tube or kinescope, or in both.

Any attempt to improve television system resolution becomes primarily an attempt to improve camera tube resolution since kinescopes capable of resolving well over 1000 lines are available; and although many technical difficulties are presented, bandwidth and scan rate can be increased as long as one is willing to pay the price. Therefore, the initial object of attention must be the camera tube.

Camera Tube

The image orthicon, although capable of somewhat higher resolution than the vidicon as normally operated, is not considered because of its bulk, complexity and high cost. However, the only vidicon generally available has a 1-in. diameter and presents the seemingly formidable problem of designing a high-resolution TV system based on a normal scanning format of 0.375 by 0.5 in.

Under normal conditions, the 1-in. vidicon is capable of a limiting resolution of only about 700 lines, and this only in the center. The corner resolution is generally found to be about 400 lines. However, deterioration of resolution in the corners, and the rather high geometric distortion normally associated with the vidicon image, are luckily not the fault of the tube, but of the deflection process and components.

Overall resolution can be improved considerably if the focus field is increased to a value well beyond the recommended 40 gauss. At 80 gauss, the limiting resolution at the center is better than 1200 lines, and the modulation, or detail contrast, at 600 lines increases from about 10% to over 30%. However, at 80 gauss the commonly used deflection components cause very serious portholetype shading and deflection defocusing.

This shading is due to the fact that deflection of the scanning beam causes the electrons to land on the target at other than normal incidence. Thus, their energy is distributed between axial and lateral components. Since only the axial component is effective in discharging the target, the surface is returned to cathode potential only at the center of the picture. Consequently, a difference in potential will exist between the center and the corners. The difference voltage, or error voltage, V_E, is equal to $Vm^2 \sin \theta$, where Vm is the mesh-to-target voltage, and θ is the angle by which the electron beam direction departs from a normal to the target surface. Since Vm varies as the square of the value of the magnetic focus field, the landing error voltage increases by a factor of four when the focus field is doubled. Thus, where the error for typical deflection components under the 40-gauss condition may be only 3 v, which is less than 10% of the normally used target voltage, it rises to 12 v, or about 30%, under the 80-gauss condition. This, of course, would cause very objectionable shading.

An additional potential defect of equal importance is deflection defocusing, which, with even the best deflection components, may cause a 2 : 1 loss of resolution in the corners. However, both landing error and deflection defocusing may be almost completely eliminated by proper deflection system design.

Deflection System

The deflection system is considered to consist of the deflection and focus coils, alignment magnet, the vidicon tube itself and electrical signals as necessary. Careful choice of field geometry, that is, effective length and relative position of the focus and deflection fields, and the placement of the tube within these fields, results in complete cancellation of landing error when the appropriate focus modulation signal is applied.

In other words, the field geometry chosen results in some signal fall-off and deflection defocusing in the picture corners. A signal of the proper shape and amplitude to correct for the deflection defocusing is applied to the vidicon cathode. This signal, at the same time, corrects the shading. Fortunately, this also happens to be the correct condition for zero geometric distortion. Here, it seems, is one of those rare phenomena of nature — a condition where it is not necessary to compromise one characteristic for the benefit of another.

Resolution performance of a camera employing these deflection components with the 7038 vidicon operating with an 80-gauss focus field is shown in Fig. 1. Corner resolution is about 80% of that at the center. For comparison, the response with a 40-gauss field is also shown.

System Parameters

Now, given a camera tube with this improvement in resolution capability, the problem of choosing optimum system parameters presents itself. The usual considerations of power frequency and flicker effects dictate the choice of a field rate of 60 cycles/sec (cps), with 2:1 interlace. Choice of line rate, or number of scanning lines pe. frame, then becomes a matter of balancing the yield, in terms of resolution or detail response, against the cost of bandwidth.

We have found that there is negligible value in preserving the vertical response of the system beyond the point where the combined detail response of the transducers drops below about 20%. Our data indicate that this point occurs at about 650 lines. Thus, a logical initial choice for system vertical resolution is about 650 lines.

To resolve 650 lines, about 900 total scanning lines are required, including about 40 for vertical blanking. However, a second consideration enters here:

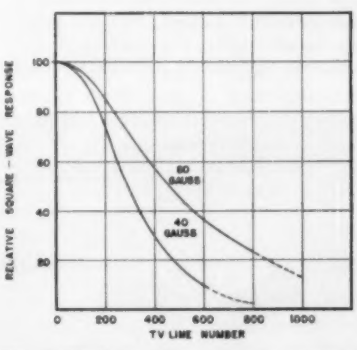

Fig. 1. Horizontal square-wave response curves, showing resolution.

Presented on October 9, 1959, at the Society's Convention in New York by L. L. Pourciau (who read the paper), M. Altman and C. A. Washburn, General Precision Laboratory Inc., 63 Bedford Rd., Pleasantville, N.Y.
(This paper was received on November 9, 1959.)

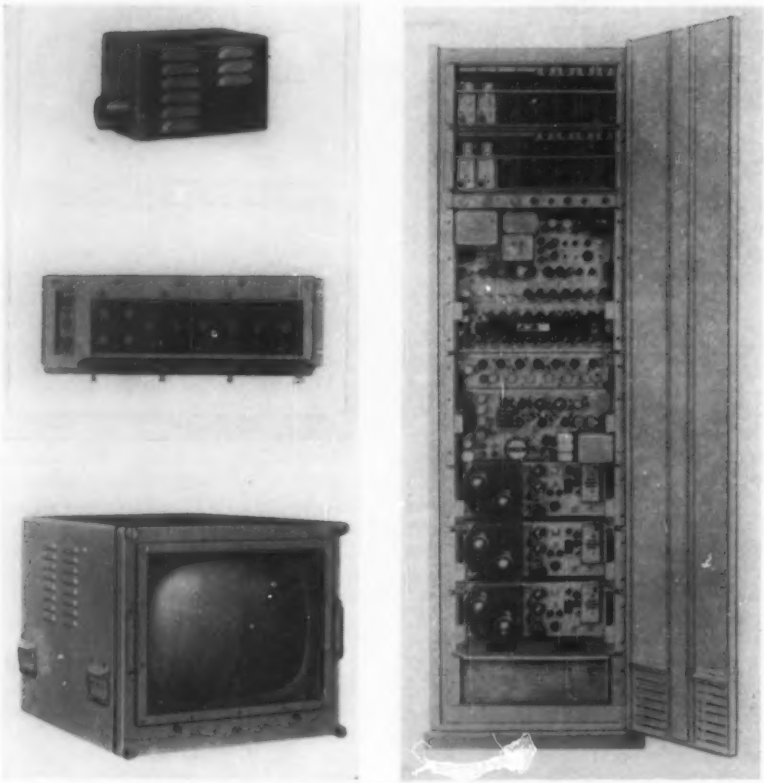

Fig. 2. System components. Left: top, camera; center, remote-control unit; bottom, 21-in. display unit. Right: electronic equipment cabinet.

The number of scanning lines per frame should be a multiple of, preferably, no more than four reasonably small prime numbers so as to allow flexibility of synchronizing generator design. The closest number to 900 that fits this additional requirement is 875, which is the number chosen.

The major remaining parameter is bandwidth. Again, the detail response criterion enters; but since loss of transducer detail response in the line direction may be to some extent compensated for, the choice becomes more complicated. Compensation for horizontal detail response loss is obtained at the expense of signal-to-noise ratio or camera sensitivity, since it involves boosting the high-frequency gain of the video amplifier. Consequently, the amount of compensation that can be tolerated is strictly limited. Experience shows the maximum tolerable boost to be in the order of four times, or 12 db. Referring again to Fig. 1, it can be seen that the response has dropped to about 13%, or −18 db, at 1000 lines. Application of 12-db boost at 1000 lines results in a response of −6 db. Further extension of the response will result in very little real gain in system capability, because the cathode-ray-tube response is also down considerably at this point. Consequently, the bandwidth has been limited to 20 mc, corresponding to a horizontal resolution of approximately 1000 lines.

Detail system parameters are:

field/frame rate: 60/30 cps,
lines/frame: 875,
field blanking: 800 μsec or 21 lines or 4.8%,
line blanking: 7 μsec or 18.5%, and
bandwidth: at 17 mc ±1 db and less than −3 db at 20 mc.

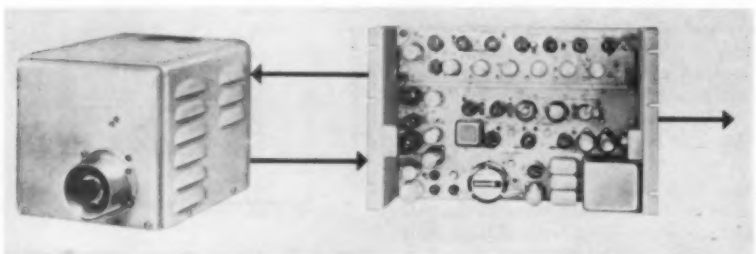

Fig. 3. Camera and camera control unit.

Equipment

A number of system components operating on these parameters have been designed for and in cooperation with the Bureau of Ships. Specifically they are:

1. Single-lens camera chain.
2. Turret camera chain with remote control of turret and optical focus.
3. Viewfinder camera.
4. Synchronizing generator.
5. 21-in. monitor.
6. 14-in. monitor.
7. Waveform monitor.

Figure 2 shows several of these components.

Camera and Camera Control

The camera and its associated camera control chassis are shown in Fig. 3. The camera contains the video preamplifier, the line sweep circuit, sweep loss protection circuits, vidicon blanking circuits and the line focus modulation circuit. The input stage is a cascode arrangement employing a 417A in the lower portion and a 6922 with the two triode sections in parallel in the upper. This combination provides an input noise resistance of about 100 ohms. This low noise resistance, combined with the low input capacity provided by careful front end design, enables surprisingly high sensitivity to be obtained. Resolution of 800 lines is maintained at a scene brightness as low as 5 ft-L with a 7038 vidicon.

The input stage is followed by a pentode amplifier which provides partial compensation for the vidicon output circuit, and then a pentode output stage. A signal polarity reversing switch is provided which enables either positive or negative presentation.

The line sweep circuit employs voltage feedback and provides linearity of considerably better than 1%. Sweep loss protection for the vidicon is provided by rectifying the line and frame sweep voltages and controlling the vidicon G_2 voltage from a combination of the voltages such that if either drops below a given limit the scanning beam is cut off.

A blower provides vidicon cooling, and the air passage is so arranged that the temperature rise measured at the vidicon faceplate is less than 10 C.

A rugged and precise mount for the vidicon is a necessity. The tube is firmly clamped by split nylon conical sections both front and rear. These are compressed around the tube envelope by threaded members. Thus, accurate alignment of the tube axis with the magnetic axis is assured.

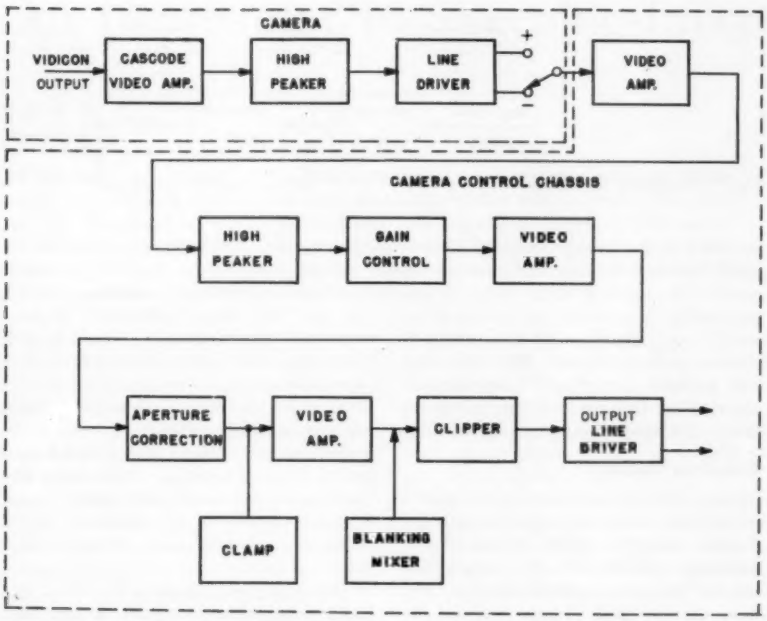

Fig. 4. Video amplifier block diagram.

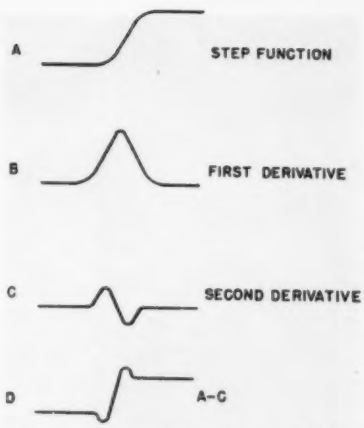

Fig. 5. Aperture correction by subtraction of second derivative.

The complete amplifier chain is shown in block diagram form in Fig. 4. The video amplifier continues on the camera control chassis. The first stage in this chassis is a straight pentode amplifier. It is followed by the second high-peaker stage which completes the vidicon load resistor compensation and, in turn, by the gain control stage. The gain control stage is balanced and provides about a 6:1 control range with very little differential gain. The next stages comprise the aperture correction circuit which boosts the high frequencies by a controllable amount to compensate for the loss in detail response caused by the finite size of the vidicon scanning beam and other system apertures.

The high-frequency boost introduced by the aperture correction circuit must, for best transient response, be free from phase error since the effect to be corrected is a physical one and does not introduce phase error. The circuit used here provides a very close approximation to the ideal by subtracting the second derivative of the signal from the signal itself. This may be illustrated rather easily in a qualitative manner.

The second derivative of the step function (a) in Fig. 5 is shown at (c). If this signal is inverted and added to (a) the signal shown at (d) results. The overshoot on (d) is symmetrical about the transition, which is an indication of linear phase response.

As diagramed in Fig. 4, the output of the aperture correction circuit is clamped, and applied to the blanking mixer stage, where blanking is added to the signal and the base line of the signal is clipped to provide clean blanking intervals free from noise, ringing and overshoots. A feedback output circuit which provides two isolated, source-terminated output signals completes the video chain. The camera chain video amplifier is flat to within about 1 db up to 20 mc.

The camera vertical or field sweep circuit is included in the camera control chassis. Like the line sweep circuit, it employs voltage feedback to provide and maintain linearity. Incidentally, no camera sweep linearity controls are necessary.

Synchronizing Generator

The synchronizing generator is designed to cover a wide range of operation — from 675 to 1035 lines at 60 fields and 30 frames/sec. The counter begins with a feedback binary count of 5, followed by an 8-stage binary chain with adjustable feedback which may be connected to provide counts of 135 (for 675 lines) to 207 (for 1035 lines).

The master oscillator is adjustable over the frequency range required for the above system parameters and may be crystal controlled, LC controlled, or locked to the power line or to an external source of 60 cps.

Horizontal drive is formed from pulses at twice the horizontal frequency obtained from a delay line with a time-delay difference equal to the desired drive pulse width. The pulse train corresponding to the leading edge is fed through a divide-by-two gate which gates out every other pulse in the train, thus providing an output at the horizontal rate. The horizontal-rate leading-edge pulse then triggers one side of a bistable multivibrator and the twice-horizontal-rate trailing-edge pulse triggers the opposite side. The output of the multivibrator is then a pulse at horizontal rate with a width equal to the time difference between the two triggers.

Horizontal blanking is produced in the same manner as horizontal drive. However, a gating signal equal in width to the vertical blanking interval is applied to one grid of the blanking bistable multivibrator to provide mixed vertical and horizontal blanking from the one stage. This gating signal, which effectively disables the multivibrator, is derived from a monostable multivibrator triggered from the counter output.

Vertical drive is also formed in a bistable multivibrator, but its triggering is somewhat complicated by the need for a delay relative to vertical blanking in order to mask the normally peak white signal obtained from the last scanning line in the field. This delay is obtained by triggering one side of a bistable multivibrator with the main counter output, and the other side with the output of the previously mentioned count-of-five, thus producing a field rate pulse $2\frac{1}{2}$ lines long. The trailing edge of this pulse then serves as the leading-edge trigger for the bistable multivibrator which provides the vertical drive pulse. The trailing-edge trigger is obtained from the sixth divider stage which fires $17\frac{1}{2}$ lines after the main divider output. Thus, a 15-line vertical drive pulse is produced with delay and width determined by the main counter.

All pulses are clipped in regenerative clippers and applied to "anode follower" output circuits with cathode gain controls. Outputs are source-terminated by means of a 75-ohm resistor to ground across the output circuit.

No composite sync signal is generated, since all cameras and monitors are operated from drive pulses to avoid interlace difficulties.

Fig. 6. Control console, with 14-in. picture monitor and waveform monitor.

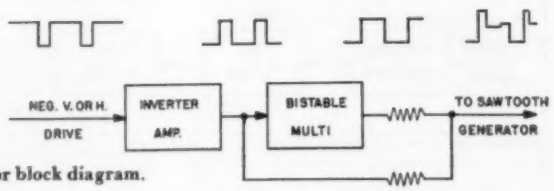

Fig. 7. Waveform monitor block diagram.

Picture Monitors

Two monitors have been designed: One a 14-in. rack mounting unit (Fig. 6), and the other a 21-in. cabinet model (Fig. 2). Both use identical circuits and employ an especially designed high-resolution cathode-ray tube. Circuits are arranged by function on subchassis which may be easily removed for service or replacement.

Excellent stability is obtained by regulation of plate supplies and the cathode-ray-tube ultor supply, and by using a permanent-magnet focusing device. Vernier adjustment of focus is provided on the front panel, by a control which actually adjusts high voltage to match the existing focus field. Focus modulation is provided by means of an auxiliary coil driven with a parabola of current at vertical rate. Both monitors will provide a highlight brightness in excess of 40 ft-L through the polarizing filters with which they are equipped.

Waveform Monitor

The waveform monitor for the system is conventional in all respects, with the possible exception of the means of providing the half-H and half-V rate pulses needed to allow presentation of two lines or two fields on the cathode-ray tube. This is shown in block diagram form in Fig. 7. It is simple enough, of course, to obtain pulses at either $\frac{1}{2}$ V or $\frac{1}{2}$ H by means of a bistable multivibrator triggered at V or H. However, this results in a square wave at the desired rate, and what is needed is a pulse with about a 5% duty cycle for application to the sawtooth generating switch tube. Differentiating the square wave results in a pulse that is too short to allow proper discharge of the sweep capacitor. A suitable waveform may be obtained rather simply by adding the inverted drive pulse to the half-frequency square wave, which results in the waveform shown at the upper right in Fig. 7.

Results

Resolution figures for 675, 875 and 1035 lines/frame are tabulated below:

	675 lines	*875 lines*	*1035 lines*
Vertical resolution....	480	630	750
Horizontal resolution (3:4 aspect ratio, 20-mc bandwidth)..	1000	1000	800

Horizontal resolution is limited by vidicon capability in the first two cases, and by bandwidth in the third. Actually, up to 1400 lines resolution has been obtained experimentally from the vidicon, but only with a selected tube, very carefully set up.

Camera sensitivity with a 7038 vidicon is such that an 800-line picture can be obtained at $f/2$, with a scene brightness of 5 ft-L. There are available more sensitive tubes which will allow an excellent picture to be obtained at $f/2$ with a scene brightness of only 2 or 3 ft-L.

Camera sweep linearity is within $\frac{3}{4}$%, and geometrical distortion is less than ± 1%. Monitor linearity is within about ± 1%, and geometrical distortion is less than $\pm 1\frac{1}{2}$%. The combination can be set up to produce a ± 1% picture except possibly for the extreme corners.

Since the system is designed primarily for black-or-white type of information transmission, gamma correction is not included. Even so, the system is capable of reproducing the EIA 10-step gray scale with ease.

Acknowledgments

The design of the system described was sponsored by the U.S. Navy Bureau of Ships, which has seen fit to adopt the 875-line, 60/30 field system as a Navy standard. Detail design was of course the result of the combined effort of many at the General Precision Laboratory. The authors would particularly like to mention Theodore A. Asplund and Urban H. Santone, Jr., in connection with the electronic design; and C. Kimball Gaertner and Leif Pedersen for their work on the mechanical design.

An Improved $f/10$ Sweeping-Image Camera

By BERLYN BRIXNER

A rotating-mirror sweeping-image camera with mirror distortion corrector, faster writing speed, and apochromatic relay lens has resolving power greater than that of earlier models. An adjustable cylinder lens corrects astigmatism from mirror surface distortion. The mirror, rotating up to 2000 rps, gives a maximum writing speed of 13 mm/μsec for about 10 μsec. The $f/10$ lens gives static resolution of 36 lines/mm on film. Time resolution is estimated at about 3×10^{-9} sec.

THE HIGH-SPEED rotating-mirror sweeping-image camera is not at all new, since it was invented by Professor Boys[1] in 1893 to determine the duration of the spark light source he was using to produce a series of beautifully clear and sharp shadowgraph pictures of rifle bullets and their associated shock waves in air. I estimate that his camera operated at about $f/30$ with a small mirror revolving at 1028 rps to give a writing speed of perhaps $\frac{1}{2}$ in./μsec and an estimated time resolution of a few hundredths of a microsecond. Since this type of camera is capable of making time measurements with greater precision than any other camera, its use has continued with increasing popularity. Such a camera has been in steady use at the Los Alamos Scientific Laboratory (LASL) in the investigation of explosive phenomena for more than fifteen years, and the one to be described represents the most advanced form of the class of cameras that make 3-in.-long slit-image records.

The principal advances in this camera have been made by applying recent improvements in the art of lens manufacture and optical testing procedure. The three most important design improvements are: (a) the use of a flat field apochromatic relay lens, (b) an adjustable cylindrical corrector lens to cancel the aberration produced when the surface of the rotating mirror becomes distorted as the mirror revolves at high speed and (c) a sweeping-image viewer to find easily the corrector lens position that gives the best optical resolution at each mirror speed.

The Optical System

The optical system of the camera consists of three main sections: an objective lens, operating in conjunction with a field lens, to make the initial image, of which the line of interest is to be recorded; a compound microscope viewfinder, with mirror; and the camera proper, composed of a relay lens with slit aperture, corrector lens, rotating mirror and film holder. Each of these sections can be considered alone since the function of each is largely independent of the others, though they must all, of course, perform together.

As shown in Fig. 1, the first section of the system consists of the objective lens L_1, which images the object O on the slit aperture S after the light has passed through the field lens L_2. The lens combination L_1 and L_2 must produce on the slit an image of the required sharpness, while at the same time L_2 must image L_1 on lens L_4 so that all parts of the image at the slit S will appear to be equally illuminated at the film F. For objectives of long focal length and narrow angle of view, commercially available lenses provide a relatively simple solution, but the problem becomes difficult for objectives of short focal length and wide angle of view. An excellent solution to this latter problem has not yet been obtained, but a plan for solving it will be discussed later under "Conclusions." The slit is a convenient image splitter as it consists of a mirror with a clear line ruled across it so that the line of interest in the image passes onto the film, and the remaining image is reflected back toward the viewing microscope.

The second section of the system consists of a 17× compound microscope MS with a mirror M so located that it receives the light reflected from the mirror surface of the slit S, which is tilted as shown so that mirror M can be located well outside the incoming light beams. The double passage of the light through the field lens L_2 is undesirable since it increases the aberrations of the viewing system. The principal aberration is curvature of field, but there is a shift in the position of the exit pupil which also complicates the viewing problem at the edge of the field.

The last section takes the light that passes through the slit S and produces an image I, which is swept across the film F. The lens L_4 images the slit at unit magnification, after reflection from the surface of the rotating mirror RM. Centrifugal forces acting on this mirror cause its surface to be deformed into a cylinder which introduces astigmatic optical power into the system and moves the sagittal focus away from the film. The

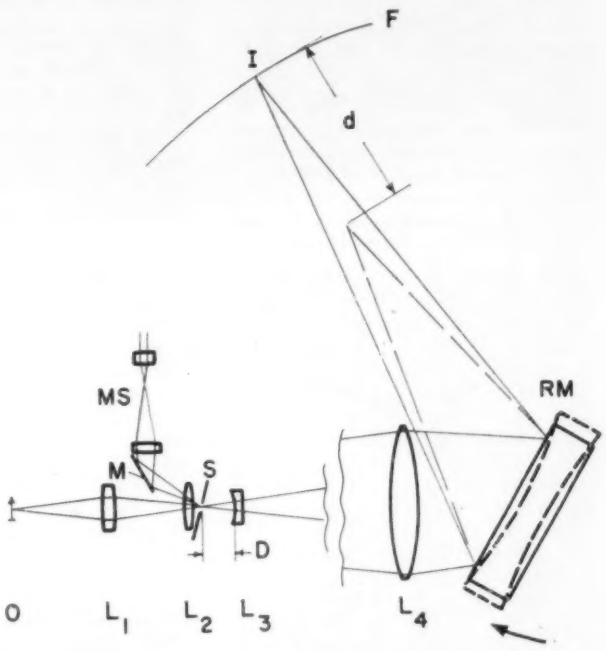

Fig. 1. Optical diagram of improved sweeping-image camera.

Presented on October 9, 1959, at the Society's Convention in New York by Berlyn Brixner, Los Alamos Scientific Laboratory, University of California, Los Alamos, N.M. The work reported here was done under the auspices of the United States Atomic Energy Commission.
(This paper was received on September 14, 1959).

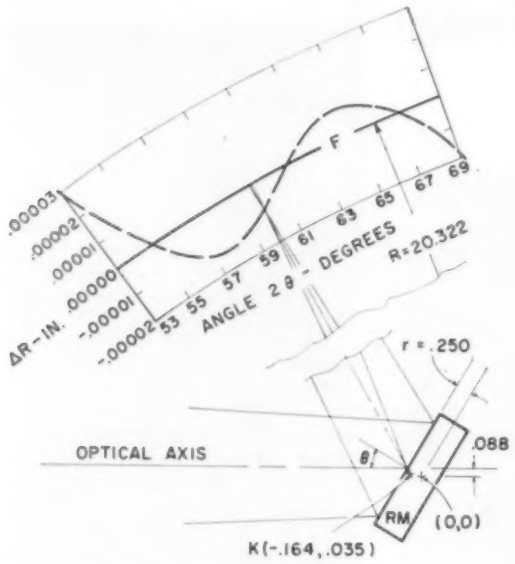

Fig. 2. Film fit to focal surface of camera.

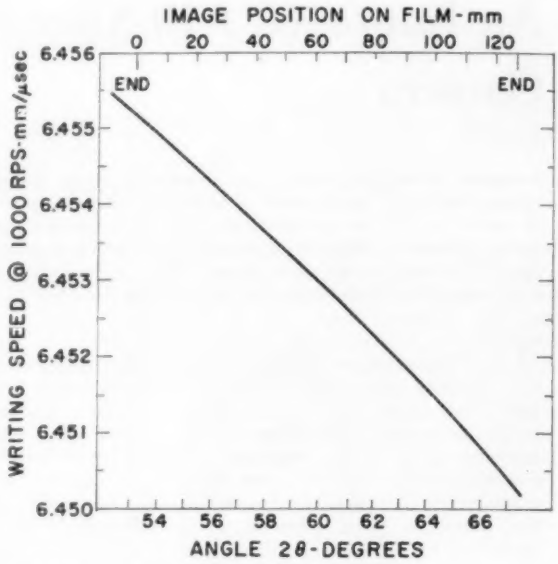

Fig. 3. Image writing speed vs. mirror angle.

negative cylinder lens L_3 can be adjusted axially, by varying distance D, to cancel most of the astigmatic power of the mirror surface so that the image remains on the film.[2] This last and main section of the camera has been subjected to the greatest amount of study because of the difficulty of controlling the several parameters involved.

If the rotating mirror has its axis of rotation in the plane of the mirror surface, the focal curve will be a circular cylinder. This is not a practical arrangement for mirrors that operate at the highest speeds, since symmetrical rotors are always used for reasons of balance. In practical symmetrical rotors the mirror surface is away from the axis of rotation, and the focal surface becomes a cylinder whose section is a limaçon given by the equations

$$x = \frac{r}{\cos\theta} + \left(\frac{r}{\cos\theta} + N\right)\cos 2\theta$$

$$y = \left(\frac{r}{\cos\theta} + N\right)\sin 2\theta$$

where x and y are the coordinates of a point on the curve, r is the distance of the mirror surface from the axis of rotation, θ is the angle of the optical axis to the mirror normal and N is the distance of the mirror axis from the axial focal point of lens L_4 if the beam is not obstructed by the rotating mirror. However, since only a small section of this curve is needed for the 5-in. film used in the camera, the curve can easily be approximated by a circular cylinder. The film is centered about the beam which is reflected when the rotating mirror is in the position $\theta = 30°$, as in the circular arc of Fig. 2. This arc has a radius $R = 20.322$ in. from the center K ($x = -0.164$ in., $y = 0.035$ in.). The departure of the circular focal surface from the limaçon surface is shown by the dashed curve. It is seen that the maximum departure of the circular film from the true focal surface is less than 0.00003 in., an error which is negligible in both theory and practice.

The writing speed on the limaçon is obtained from the equation

$$S = 2\,(r^2 + N^2 + 2rN\cos\theta)^{1/2}\,\frac{d\theta}{dt}$$

where S is the writing speed and $d\theta/dt$ is the mirror velocity.[3] The writing speed on the circular film differs from the speed on the limaçon by less than 0.001% and hence is not significant for this design. In fact, the writing speed varies by less than 0.1% from one end of the film to the other, as shown by the graph in Fig. 3.

The relay lens L_4 is operated at a magnification of 1:1, and with this condition the corrector lens L_3 is positioned according to the equation

$$D^2 = df_3$$

where D is the distance of the lens from the slit, d is the shift of the image as a result of distortion of the rotating mirror surface and f_3 is the focal length of the simple plano-concave cylinder lens L_3. A practical value of f_3 is obtained by calculation from the measured value of d, which is obtained by the use of a sweeping-image viewer[2] with the rotating mirror and relay lens used in the camera. The focal length of this lens is not critical since its effective power in the system is readily adjustable over a wide range.

Construction Features

The camera is shown in Fig. 4 with the side of the case removed to expose the interior. A 52-in. machined length of channel iron is the camera bed. The objective lens *2* is a Kodak-Ektanon 10-in. *f*/4.5 mounted on a manually operated dovetail slide for focusing. From left to right, an Ilex No. 5 shutter follows the objective lens. Farther to the right is the 8.8-in. focal length, plano-convex field lens *3* and the slit and its holder *4*. This slit and the remaining components are all mounted on the camera box casting. Just to the right of the slit is the plano-concave cylinder lens *5*, of −100-in. focal length mounted on an adjustable slide. The relay lens *6* is a Kodak Z-80 apochromat of 15-in. *f*/4.5 for operation at 1:1 conjugates with an effective aperture of *f*/9. The rotating mirror *7* is the LASL MOD-225 turbine-driven rotating mirror, ½ by 2 by 3 in., for operation at a maximum speed of 2000 rps. The mirror is supported on ball bearings and reaches its maximum speed with an air pressure of 80 psi. The film cassette *8* is custom built to hold the film in the required circular arc and is quickly detachable for transfer to the darkroom.

The relative positions of the film holder, rotating mirror, relay lens, and way for the cylinder lens slide are not adjustable since they are determined by the machined positions in the casting which forms the body of the camera. This method of mounting the components was employed in preference to an adjustable scheme because the theoretical positions of the components are known, and machine shop practice easily locates these positions with the required accuracy. Because each relay lens has a slightly different focal length from the others and because it is desirable for these lenses to be easily replaced, the slit holder *4* is adjustable. The adjustment

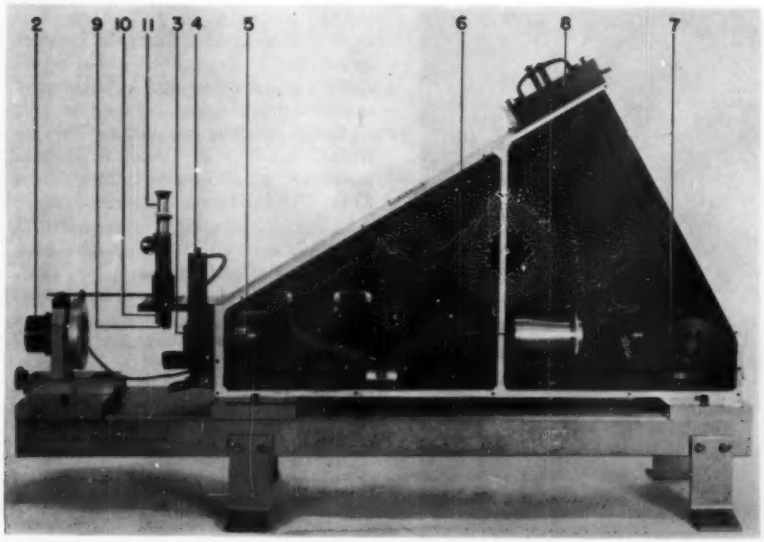

Fig. 4. View of improved sweeping-image camera.

Fig. 5. Photoelectric synchronizer.

is made with a shim whose thickness is determined by photographing resolution targets in the slit plane with a series of shim thicknesses to obtain the optimum distance for best resolution at the film plane.

Light reflected from the mirror of the slit plate is reflected from the mirror *9* into the compound microscope consisting of a 60mm (1.7×) objective *10* and the 25mm (10×) eyepiece *11*. The microscope can be translated laterally so that all parts of the 3-in.-long slit can be observed. The microscope must be rotated about its axis to avoid vignetting at the ends of the slit. The required rotation is automatically obtained by the arm which extends to the left and is pivoted at the objective lens holder.

In order to record the image on the film it is necessary to synchronize the detonation of an explosive object with the angular position of the rotating mirror. This camera uses a photoelectric synchronizer (Fig. 5), which has an incandescent light beam reflected from the rotating mirror and folded back to sweep across a slit aperture in front of a 931A photomultiplier tube which, in conjunction with its power supply (not shown), produces a pulse for timing the detonator firing. The assembly shown surrounds the rotating mirror drive and is fastened onto the camera cover. The assembly may be rotated through a maximum angle of 70°, which at the highest speed gives a pulse about 100 μsec in advance of recording time.

The engineering drawings of this LASL MOD-72A camera and the MOD-225 turbine drive (21Y16218 and 21Y-16206) are available at nominal cost.*

* From the U.S. Atomic Energy Commission, Technical Information Service, P. O. Box 62, Oak Ridge, Tenn.

Performance

The performance of the camera was evaluated by examining the visual and photographic images at both the slit aperture and the film surface. Initial examination of the static visual images of the individual components permitted evaluation of the relative performance of each. Then, the assembled components were tested as a unit, first in the static condition and later dynamically. Finally, the evaluation of the overall performance of the camera was made from observations with the sweeping-image viewer and measurements of photographic images.

The Kodak-Ektanon 10-in. *f*/4.5 objective lens used at *f*/9 and operating at a magnification of 1:18 was found to give white-light visual resolution of 100 lines/mm on a 3-in.-long slit. This resolution was lowered to 40 lines/mm at the slit ends when the simple 8.8-in. field lens was introduced in a position just in front of the image. The loss of resolution was mainly due to the increased curvature of field. Many other commercially available lens combinations were tried, but none better was found.

The Kodak Z-80 15-in. *f*/4.5 apochromatic copy lens for operation at a magnification of 1:1 was found to give a 100-lines/mm colorless white-light image across the 3-in. field. The introduction of the simple cylinder lens and the static rotating mirror caused some loss of image contrast, but the resolution was substantially unchanged. The cylindrical corrector lens distance *D* was varied over the full range, and the resolution was maintained on the astigmatic fields even though they became widely separated.

To test the camera's static photographic resolution, the objective- and field-lens combination with its lower resolution was removed from the optical train, and the slit was replaced by a series of miniature high-contrast transparencies of the National Bureau of Standards resolution test charts. These charts were illuminated by a broad ground-glass light source and recorded at the cylindrical focal plane on Kodak Panatomic-X film developed in D-19 for 6 min. This test showed that resolution of 36 lines/mm could readily be obtained on all parts of the film. The loss between visual and photographic resolution represents good performance under the conditions specified.

Since light sources of sufficiently short duration were not available for dynamic photography of resolution charts, the dynamic photographic resolution was estimated from observation of the film-image contrast and sharpness in records of high-explosive phenomena and from visual resolution observations made with the sweeping-image viewer.[2] These observations indicated that image resolution of substantially static quality was maintained at rotating mirror speeds up to 1200 rps, but at higher speeds the mirror surface distortion apparently became noncylindrical and could no longer be fully compensated by the corrector lens. Figure 6 shows a resolution chart which was photographed through the sweeping-image viewer while the mirror was rotating at 1200 rps. The photograph at the left was made without astigmatic correction; the one on the right with correction. These photographic images were degraded by the double passage of light through the optical system. The resolution on the original negative was 20 lines/mm. At 1200 rps the camera's time resolution is estimated to be

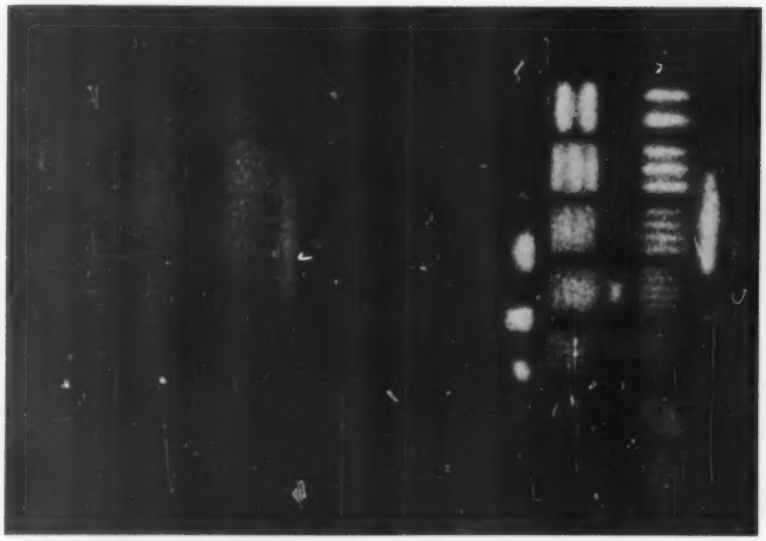

Fig. 6. Resolution targets photographed at 1200 rps without and with astigmatic correction.

3×10^{-9} sec or better. Although the turbine-driven mirror was designed to operate up to a maximum of 2000 rps to give a writing speed of 13 mm/μsec for about 10 μsec, the time resolution at speeds above 1200 rps has not yet been thoroughly investigated.

Conclusions

This camera has demonstrated a time and space resolution superior to that obtainable with the earlier models used for investigations of explosive phenomena. This improvement is observed on the photographic negative in the form of images with greater density and contrast than those previously obtained. The earlier Los Alamos camera required a 0.004-in.-wide slit to obtain adequate image density. The 0.002-in.-wide slit now in regular use on the new camera gives higher density and contrast than was obtained with the old camera with a 0.004-in. slit. It is believed that a 0.001-in.-wide slit would still produce adequate negative density and contrast and at the same time improve the resolution obtainable, but there is insufficient experimental information available at present to evaluate this possibility.

The objective- and field-lens combination is the optical element most in need of improvement since its resolving power at the edge of the field is only one-fourth the theoretical value. For this specific function, a six-element lens similar to profile projection lenses has been designed, and a prototype is being built. Multiple raytracing yields information about the image spot sizes which suggests a resolution of 100 lines/mm on all parts of the slit image. If this expectation is attained, the lens will be fully equal to the quality of the relay lens, and little additional future improvement can be expected for the optics since the overall space resolution will then be about two-thirds the theoretical.

The Kodak Z-80 relay lens was especially designed to meet the requirements of this camera, but it was subsequently found that some commercially available lenses could be used to give similarly excellent resolution. For instance, two Taylor, Taylor & Hobson Series IX apochromatic process lenses 25 in. $f/10$ can be used in series to make a 12.5-in. $f/5$ lens which is then used at a magnification of 1:1. This combination also gives 100 lines/mm on a 3-in. field. For use in the above described camera, this two-lens combination gives performance comparable to that yf the Z-80 in light transmission, back focal distance, resolving power and image contrast. It is probable that other lens combinations would also be equally useful.

The camera has generally exceeded the users' expectations despite the obvious deficiencies that exist and has given very reliable operation for the past several years.

Acknowledgments

My thanks go to Dr. R. L. Spaulding for encouraging me to build this camera, to Ernest Cohen for some of the measurements of the optical components, to Charles G. Phelps for preparing the mirrors and simple lenses, to Thomas E. Deem for diligent and painstaking attention to the fitting and assembly of the many camera parts, and especially to Eugene A. Igel for his detailed supervision of all aspects of the construction and testing of several of these cameras.

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New Observations of Explosive Phenomena by Submicrosecond Color Photography

By MORTON SULTANOFF
and ROBERT L. JAMESON

Successful color photography at submicrosecond exposure times has been achieved by use of recently developed cameras, emulsions and lighting techniques. The study of explosives has been extended to include heretofore unobserved phenomena by use of the Beckman & Whitley 25-frame reimaging camera operating at exposure times of 0.12 μsec. Super Anscochrome film, force-developed for both maximum exposure index and restoration of color balance, exposed to the direct light of the explosion and the reflected light of argon-filled explosive flashlamps, produced unexpected fidelity of color, and revealed events not previously recorded with black-and-white films. An animation, produced and played back as a motion-picture sequence (shown as part of the oral paper), reveals and clarifies the motion of these newly recorded phenomena.

THE BALLISTIC RESEARCH LABORATORIES are engaged in studies of the basic physical phenomena involved in explosive reactions. The high propagation velocity of the reactions, plus the high luminous output, has led naturally to the adaptation of ultrahigh-speed photographic instrumentation to these studies. The explosive events have velocities of about $\frac{1}{8}$ to $\frac{1}{2}$ in./microsecond (μsec) and, specifically in our studies, exposures are finally examined at magnifications of 1:1 or larger. This requires that exposure times be of the order of $\frac{1}{10}$ of a microsecond (0.1 μsec), or the desired detail would be lost in exposure blur.

Successful black-and-white records have been obtained consistently with available commercial equipment. However the identity of some phases of these events is lost in the lack of contrast. The possibility that "color contrast" might overcome this difficulty was investigated. A study of the event, the recording equipment, lighting possibilities, and the "forcible super-speeds" of Super Anscochrome film resulted in successful full-color photography which led to the identity of features in the explosive reaction which had not been previously observed.

EXPERIMENTAL PROCEDURE

Analysis of Experimental Requirements

The Beckman & Whitley 25-frame reimaging high-speed camera has been used successfully to study explosive events with black and white film exposed to the light radiated from explosive events. With this knowledge as a background and with the selection of the fastest known color film (Super Anscochrome), a study of the following components of the complete system was made:

(1) The Explosive Event
(2) Lighting
  (a) radiated (from the event)
  (b) reflected (front lighted)
  (c) transmitted (back lighted)
(3) The Camera
(4) The Film
  (a) exposure
  (b) development
(5) Synchronizing and coordination of all components
(6) Animation for motion-picture analysis

The Explosive Event

Physical conditions leading up to full reaction (detonation) in an explosive were studied by arranging two charges of a standard military composition (50/50 pentolite) as shown in Fig. 1. The donor charge is initiated electrically by standard techniques, and this charge is consumed at the rate of $\frac{1}{4}$ in./μsec by a very high pressure shock front supported by the chemical reaction. This shock produces highly luminous lateral air shock from the sides of the charge, and upon reaching the end sends out an air shock which impinges on the face of the second (receptor) stick. It would be expected that this strong shock influence would cause immediate reaction in the second stick at the impacted end. However, an incompatible physical discontinuity to the detonation of the second stick was observed in streak and framing camera records. This observation led to additional testing, the purpose of which was to determine why indications of the transfer of energy to the detonation in the second stick were not observable. Plaster of Paris "blast-shields," through which the charges extended, were cast around the ends of each stick to prevent the detonation gases and other products from spilling over and obscuring the second stick during the period of delay (0 to 50 μsec) until the appearance of the detonation in the second stick.

Lighting

The light radiated from the explosive event identified both the detonation front and the very highly luminous air shock associated with the reaction. In

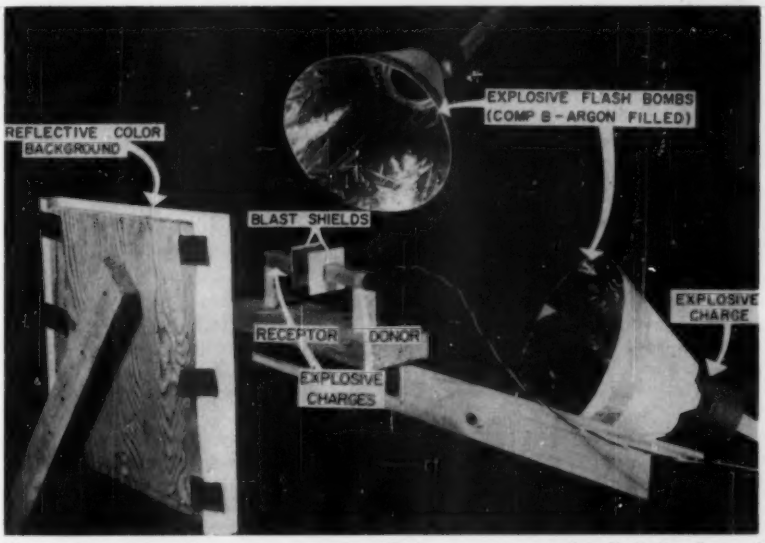


Fig. 1. Experimental arrangement of explosive event, explosive flash bombs and reflective background.

Presented on May 4, 1959, at the Society's Convention in Miami Beach, by Morton Sultanoff (who read the paper), and Robert L. Jameson, Ballistic Research Labs., Aberdeen Proving Ground, Maryland.
(This paper was received on November 9, 1959.)

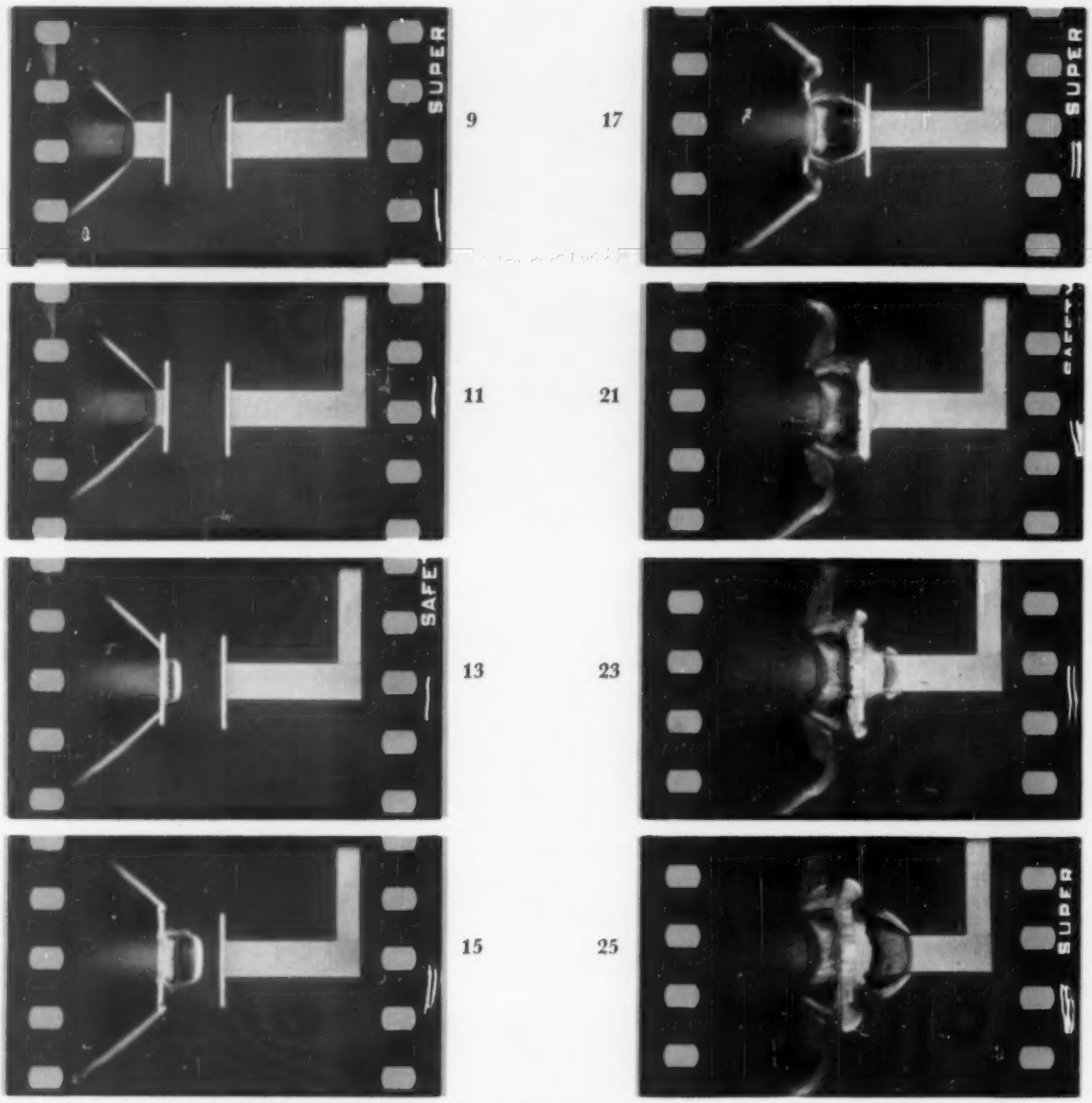


Fig. 2. Selected frames of explosive event duplicated directly from the Beckman & Whitley camera record, taken at the Ballistic Research Laboratories at Aberdeen Proving Ground, exposed on Super Anscochrome color film. The number beside each frame indicates its position in the series of 25 exposures. (Publication of color illustration courtesy of Ansco.)

order to define the surface of the charges ahead of the reaction, however, it was necessary to "front-light" to obtain exposure by reflection. The reflected intensity required for adequate exposure of the relatively slow color film at exposure rates as short as 0.1 μsec could be obtained by the use of explosive flash bombs. Past experience had shown that the spectral output of these bombs, prepared with an argon atmosphere, approximated daylight quite closely.

Balanced illumination was arranged by placing two bombs at 45° positions from the event as shown in Fig. 1. These bombs were fabricated by rolling heavy drafting paper into truncated 45° cones approximately 10 in. across the base and 7½ in. high. A charge of Composition B explosive was fitted into a cardboard cylinder 3 in. high and 3 in. in diameter and attached to the end of the cone as shown in Fig. 1. The paper cone was lined with 0.002-in. aluminum foil, and the front of the cone was closed with Saran wrap carefully stretched and taped to avoid wrinkles and creases. The luminous output which resulted from the passage of the shock from the 3-in. charge through an atmosphere of argon "freeflowed" into the cone just before firing, persisted at a fairly uniform and high level for about 35 μsec and could easily be synchronized with the 20-μsec recording time of the camera. The surfaces of the experimental charges ahead of any luminous reaction could be continuously observed by the reflected light from the argon flash bombs.

Early in these experiments it was obvious that if physical distortion of the explosive charges was to be observed the profile must be accurately observed. Since backlighting would enhance the detection of edge or surface distortion, a

background of high color contrast was arranged as shown in Fig. 1. Metalized screens, beaded screens and polished and matte papers of a large variety of colors were tested. Several red shades of a fluorescent paper marketed by Norco Mfg. Co. under the trade name of Velva-Glo all gave extremely good results. There was no glare or "hot-light" reflections from these papers, and the intensity and selective color of the backlighting which they afforded with the light from the two flash bombs resulted in a pleasing sharp color in contrast with the pentolite charges.

The Camera

The Beckman & Whitley 25-frame reimaging camera has been described in detail in many past reports. Its high degree of reliability and usefulness in explosive tests was again demonstrated, and particularly it should be noted that in these firings the $f/27.0$ aperture, the 0.12-μsec exposure time and the good resolving power produced images which readily led to close frame-by-frame scrutiny and animation for motion-picture viewing. It should be noted that these Laboratories adapted a "fiducial" marker to this camera, which greatly simplified the animation operation and increased the accuracy of frame-by-frame quantitative studies. This invention, in the process of being patented, will be described in another publication.

The Film and Processing

Several different films were tested for color sensitivity and balance, and it was determined that Super Anscochrome, despite its normal rated ASA speed of 100, could be pushed to give color density and saturation which were highly satisfactory. After much experimentation with processing times for daylight and tungsten emulsions, color test strips exposed along with the explosive test produced strikingly true color rendition on Daylight Super Anscochrome when force-developed in the standard Ansco processing kit. A 30-min first development and a 36-min color development, along with all other standard times in the processing procedure as outlined on the Ansco processing instruction sheet, produced the results shown in the color reproduction shown in Fig. 2.

Synchronization

The explosives under study had an event time of approximately 15 μsec. The Beckman & Whitley Model 189 Camera, running at full normal speed of 1,200,000 frames/sec, had a full recording time of 20 μsec, and the explosive flash bombs had a usable persistence of about 30 μsec. The camera has a built-in signal generator which puts out signals related to the mirror position. This signal directly pulses the firing of the argon flash bomb circuit and is delayed about 3 μsec to the explosive charge firing circuit. Thus the position of the mirror, when correct for exposure in the camera, actually activates the events in proper time relationship to produce the desired exposure on the film strip.

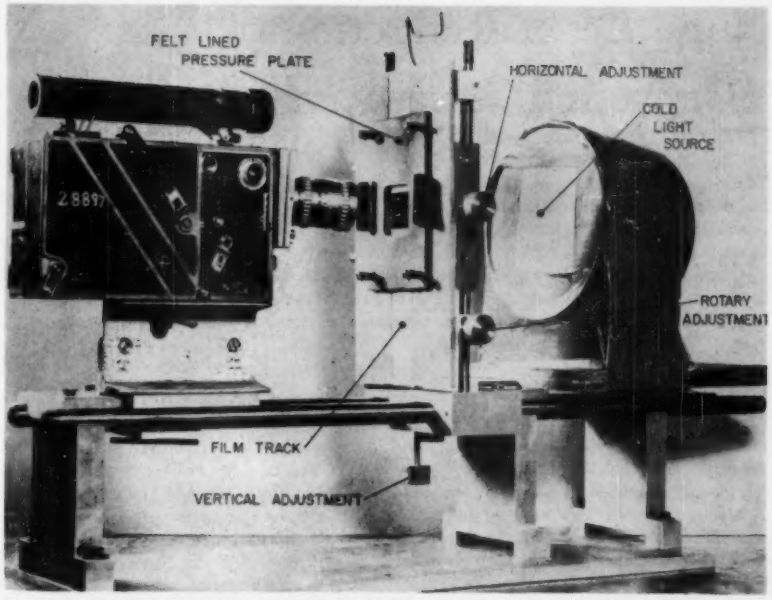


Fig. 3. Device for the animation of individual frames for motion-picture viewing.

Animation

The strip of 25 separate exposures of the event can be studied frame by frame, and quantitative data can be obtained. However, it is common knowledge that with "flicker vision" of motion-picture viewing many details can be picked out which are not observable in the individual frames. The device shown in Fig. 3, which has been fully described in a Ballistics Research Laboratory report, is used to rephotograph the frames on a standard 16mm film strip for animation from the individual frames. The best viewing results when two 16mm frames are made of each of the original exposures. The resulting film, projected at 16 frames/sec, gives a time magnification of approximately 170,000 : 1.0. Some "jump" between frames is observable because of the short original exposure time with "no-blur" recording, but ghosting exposure techniques, with successive frame fade in and out, did not improve the projection quality.

RESULTS

The obvious preliminary shock in the receptor explosive stick, which explains the heretofore incompatible physical discontinuity to detonation in that charge, can be seen in the selected frames reproduced in Fig. 2. The full value of the color exposures, run as motion pictures after animation, is vividly revealed by projection of the 16mm film made available to the SMPTE for the 85th Semiannual Convention.

Acknowledgments

The authors wish to acknowledge the assistance of V. M. Boyle, J. Paszek and A. J. Kreiss in the experimental firings and photographic techniques reported in this paper. The suggestions and sample materials supplied by David Oakley, Lawrence Radiation Laboratory, Livermore, Calif., were also appreciated.

Noise Level Reduction of "Depressed" Freeways

By MICHAEL RETTINGER

The paper describes a method of determining the sound level reduction afforded by "depressed" roadways, i.e., traffic lanes which are located below the general elevation of adjacent residential or industrial areas. It is based on the well-known optical case of light passing a knife edge and causing a diffraction pattern or a light shadow to exist below the edge. Various means are discussed to increase the sound level reduction, as by partially closing in the roadway, erecting a barrier near its edge, slanting the roadway banks to achieve a desirable deflection of the noise "rays," or combinations of these means.

THERE IS a fascinating chapter on community noise and city planning, by K. N. Stevens and J. J. Baruch in Cyril M. Harris' new *Handbook of Noise Control*. It is suggested therein that contemplated sources of noise within a given locality need not be prohibited as long as the radiated power does not exceed so many watts with such and such a spectrum. The example cited concerned a jet-engine manufacturer. But what about the most common type of increasing and unwanted sound — traffic noise. A large amount of U.S. freeway construction within the next few years will take place near motion-picture studios and drive-in theaters. Such projects frequently raise the question as to what can be done to prevent transmission of the increased traffic noise to these areas so that they may continue to exist. Already an enormous amount of very expensive "looping" or dubbing-in of dialogue is required by certain studios near heavy traffic arteries before intelligible films can be released. Increased traffic noise produced by freeways will obviously aggravate the condition considerably. Now is the time to consider these questions analytically so that proper measures may be taken in planning. The question arises as to how much noise level reduction is obtainable by "depressing" a freeway, that is, by constructing it so that its "bed" will be below the elevation of the adjoining studio or theater. The following calculations for the noise level reductions follow the pattern laid down earlier,* and will therefore be noted but briefly here.

The top of Fig. 1 shows the general geometric configuration employed in calculating the sound level reduction of a wall or barrier, while the bottom of Fig. 1 shows it for the sound level reduction of a depressed roadway. In each case a value v is first determined, consisting of a factor $[2a \cos \alpha/\lambda b\ (a + b)]^{\frac{1}{2}}$ and a factor p, the vertical distance between the boundary of the acoustic shadow A and the observation point B of the diffracted sound. The sound level reduction, *SLR*, in decibels, is then obtained by means of the equation

$$SLR = -3 + 10 \log \left[\left(\tfrac{1}{2} - x \right)^2 + \left(\tfrac{1}{2} - y \right)^2 \right] \quad (1)$$

where x and y are functions of v and may be obtained from tables of Fresnel integrals or from Fig. 2. The theory is based on the well-developed case for the distribution of diffracted light over a knife edge. The optic analogy is perfectly valid, because both sound and light are wave phenomena. The only assumptions underlying the optic and therefore also the acoustic theory are that the wavelength λ is very much smaller than either a or b, and that p is much smaller than $a + b$ or $(a/b)\ (a + b)$. These assumptions are in general fulfilled for the acoustic case, in which the pertinent wavelength seldom exceeds a few feet, and where the wall heights or residential area elevations are rarely more than 10 or 20 ft above the source of noise.

In Fig. 1 the distances p have been slightly exaggerated for the sake of a better diagram. Thus, p is only about a third of $a + b$ and a sixth of $(b/a)\ (a + b)$, whereas for p to be much smaller than either of these terms, the angle α should have been made smaller, providing a p which is in the order of a tenth of $a + b$ or $(b/a)\ (a + b)$. When that is taken into consideration, the term $\cos \alpha$ in the formulas of Fig. 1 becomes of such a magnitude that its square root value approaches unity. In other words, for most practical calculations, the term $\cos \alpha$ may be omitted. It was introduced because the terms a and b, as employed in the analogous optical case, refer to the corresponding radial distances along OA, which are difficult to measure in practice unless the angle α is known. As noted above, however, for most practical

Presented on May 6, 1959, at the Society's Convention in Miami Beach, by John E. Volkmann for the author, Michael Rettinger, Radio Corp. of America, Film Recording Eng., 1560 N. Vine St., Hollywood 28. This paper in slightly different form appeared in *Noise Control, 5:* pp. 12–14, 54, July 1959.
(This paper was received on March 31, 1959.)

* The similar question of what sound level reduction is afforded by a wall or barrier along a freeway or airport was discussed by the writer in "Noise level reductions of barriers," *Jour. SMPTE, 66:*391–393, July 1957.

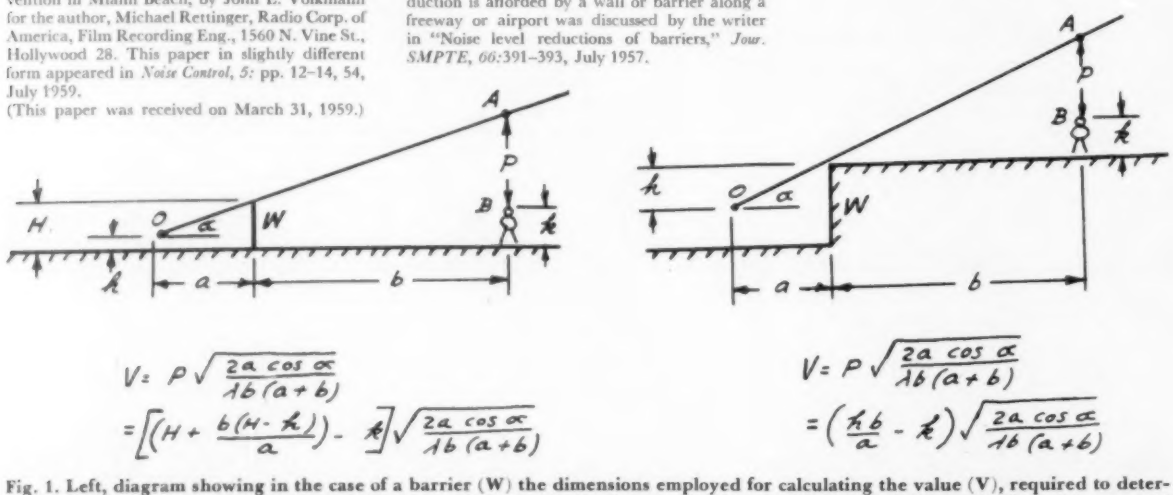


Fig. 1. Left, diagram showing in the case of a barrier (W) the dimensions employed for calculating the value (V), required to determine the barrier's sound level reduction by means of Fig. 2. Right, diagram showing similar required dimensions for a "depressed" roadway.

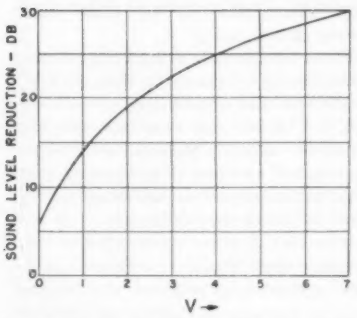


Fig. 2. Curve giving sound level reduction of barriers and "depressed" roadways as a function of the quantity (V), graphically illustrated in Fig. 1.

sound level determinations, this angle need not be considered.

Figure 2 shows a plot of the sound level reduction (Eq. 1) as a function of the v's given in Fig. 1. For instance, considering first the bottom part of Fig. 1,

a = distance between source of noise and edge of embankment, 50 ft;
b = distance between edge of embankment and observer, 500 ft;
h = depth of source of noise below elevation of observer ground, 10 ft;
k = height of observer, 5 ft;
λ = wavelength of sound, 2.26 ft;
$\cos \alpha = 0.98$;

$$v = \left(\frac{10 \times 500}{50} - 5\right) \sqrt{\frac{2 \times 50 \times 0.98}{2.26 \times 500\ (50 + 500)}}$$

$$= 1.2$$

This value of v, according to Fig. 2, corresponds to a sound level reduction of 15 db.

Figure 3 shows the sound level reduction characteristics afforded by depressed roadways for various noise source depths, h, and distances a and b as illustrated in the diagram on the top part of the figure.

Figure 4 shows, again in a somewhat exaggerated form for the sake of a better illustration, various types of depressed freeway construction, all of which provide at 500 cycles the same sound level reduction. Shown also in Fig. 4 is the case of a freeway along which is a wall or barrier which gives an equal sound level reduction of 22.5 db.

Depressed roadways can provide a sound level reduction equal to that obtained by roadways bordered by walls. They may be more costly, however, not only because millions of tons of dirt have to be moved, but also on account of the added problem of rainwater drainage. On the other hand, depressed roadways are probably more pleasing than concrete walls lining these traffic arteries.

Raised freeways, of course, afford no noise level reduction whatsoever, and rows of trees or bushes along roadways are similarly ineffective. Noise level measurements made by this writer along

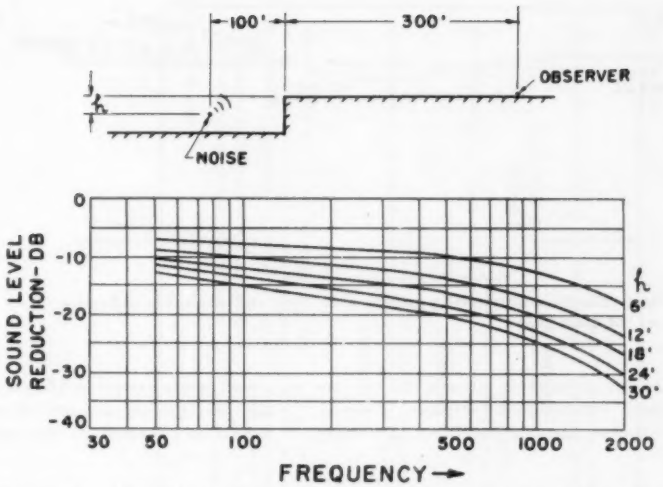


Fig. 3. Sound level reduction characteristics of "depressed" roadways for various noise source "heights" (h).

part of a road lined with eucalyptus trees, and along another part of the same road not lined with trees showed less than a one-db level reduction everywhere within 300 ft of the road. These tests were made with a half-octave bandpass filter, and employed a diesel engine truck for the noise source.

Similar considerations hold, of course, for airfields, which are faced with the added problem that, once the aircraft is in flight (above wall height) the depression or barriers become relatively ineffective.

It should be noted that the discussed noise level reductions should be added to those normally resulting from the spherical spreading of the waves.

The question arises now as to what can be done when the amounts of reduction shown in Fig. 2 are considered insufficient. There are a few solutions, practically all of which concern themselves with "closing in" the freeway overhead, the ultimate closure representing a tunnel. Some relief will be afforded when the walls facing the traffic are lined with an acoustic material, as that will tend to lower the signal level. The material obviously would have to be very durable,

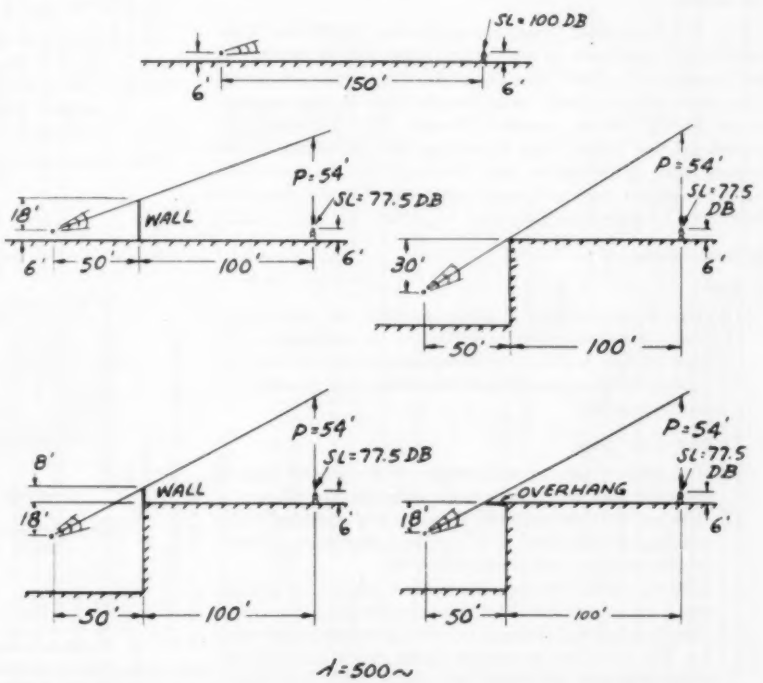


Fig. 4. Diagrams showing various means of roadway construction to obtain, for the particular case illustrated at the top of the figure, a sound level reduction of 22.5 db.

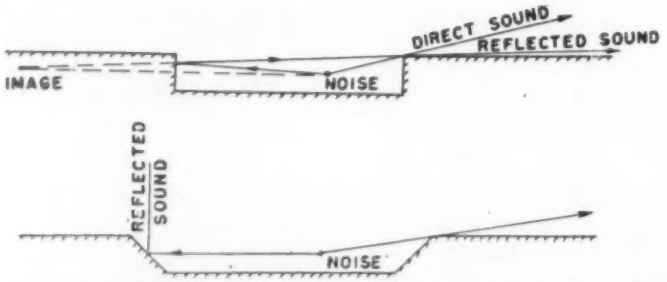


Fig. 5. Diagram illustrating undesirable (top) and desirable deflection (bottom) of noise "rays."

possibly of concrete, since it will be constantly exposed to the weather. There is, of course, also the possibility of erecting a wall beside a depressed freeway to allow an even greater acoustic shadow than would be obtained by the walls of the depression alone, or by some other means shown in Fig. 4.

To avoid the noise reinforcing effect of reflections, it is desirable to slant the walls of the roadway depressions, as shown in Fig. 5. This becomes even more effective when the slanting portions are planted to iceplant or other dense greenery, as this constitutes ground absorptivity which tends to absorb stray reflections.

The cost of all of these types of construction must, finally, be weighed against the comfort that is given the resident near a freeway (a knotty problem of psycho-acoustics) and the extent by which land and property value will remain elevated (with a consequently high tax revenue). Truly, quietness these days comes at a premium.

standards and recommended practices

SMPTE Recommended Practice Approved

Proposed SMPTE Recommended Practice, RP 5, Patch Splices in 2-in. Video Magnetic Tape, published in the October 1959 *Journal* for trial and comment, was approved without change by the Society's Board of Governors on February 12, 1960 at its quarterly meeting.

A copy of this Recommended Practice may be obtained without charge upon request directed to J. Howard Schumacher, Staff Engineer, at Society Headquarters.

SMPTE Recommended Practice RP5

Patch Splices in 2-in. Video Magnetic Tape

Introduction

This Recommended Practice originated in the Video Tape Recording Committee as a Proposed American Standard. At the November 12, 1958, meeting of the Committee it was decided that industry needs could best be met in this instance by an SMPTE Recommended Practice. The proposal, approved by the Video Tape Recording and Standards Committees, was published in the October 1959 Journal. The recommendation received final approval by the Society's Board of Governors on February 12, 1960.

Recommendations

1. *Scope*

1.1 This Recommended Practice specifies the dimensions and location of patch-type splices in magnetic video tape of 2-in. width. The recommendations are intended primarily for application in recording and reproducing studio practice.

2. *Location of the Splice*

2.1 The angle of the cut with respect to the guided edge of the tape shall be as given in the diagram and table.

2.2 The cut shall be centered between two recorded video tracks and so located as to maintain continuity of video synchronizing pulse timing (Note 1).

2.3 The separation between the two cut edges after splicing shall not exceed 0.001 in. at any point along the cut.

2.4 The longitudinal distance between corresponding points on the recorded transverse video tracks immediately preceding and following the splice shall not depart from the average distance between successive tracks by more than ±0.0005 in. (Note 1).

3. *Splicing Tape*

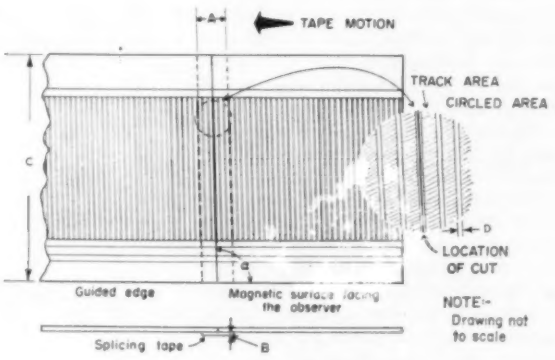
3.1 The dimensions of the splicing tape shall be as given in the diagram and table.

4. *Characteristics of the Splice*

4.1 The splicing tape on a finished splice shall not extend beyond the edges of the magnetic video tape.

4.2 The guided edge of the magnetic tape on either side of a splice shall lie on a common straight line when the tape surface is constrained to lie in a plane.

Note 1: Paragraphs 2.2 and 2.4 apply only to recorded tapes.



Dimension	Inches
A Width of splicing tape	0.25 nom
B Thickness of splicing tape	0.0007 max
C Width of magnetic tape	2.0 nom
D Distance between recorded tracks	0.0056 nom
α Angle of cut	90° 33′ ± 3′

American Standard

Threaded Lens Mounts for 16mm and 8mm Motion-Picture Cameras

ASA
Reg. U.S. Pat. Off.
PH22.76-1960
Revision of
PH22.76-1951

*UDC 778.53:771.352

1. Scope

1.1 This standard specifies the dimensions required for mechanical and optical interchangeability of lenses for 16mm and 8mm motion-picture cameras. For 16mm cameras with threaded lens mounts, threads having a nominal major diameter of 1 in. are often specified. Similarly, for 8mm motion-picture cameras, threads having a nominal major diameter of ⅝ in. are in common use.

1.2 This standard does not apply to continuous-type motion-picture cameras because of the type of optical systems employed in these cameras.

1.3 The notes are a part of this standard.

2. Dimensions

2.1 The dimensions shall be as specified in the diagram and table.

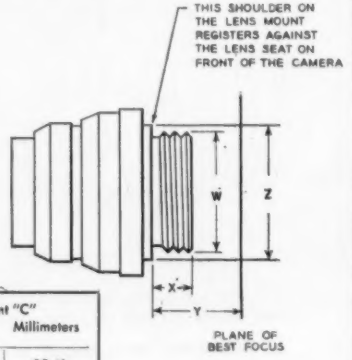
2.2 The lens mounts shall have 32 threads per inch.

2.3 The form of the thread shall be in accordance with American Standard Unified and American Screw Threads for Screws, Bolts, Nuts, and Other Threaded Parts, B1.1-1949.

2.4 Limiting dimensions and tolerances of the threads shall be class NS-2A for the external threads on the lens. These dimensions shall include plating or any other finish.

3. Revision of American Standard Referred to in This Document

When the following American Standard referred to in this document is superseded by a revision approved by the American Standards Association, Incorporated, the revision shall apply: American Standard Unified and American Screw Threads for Screws, Bolts, Nuts, and Other Threaded Parts, B1.1-1949.



Dimension	Mount "D" Inches	Mount "D" Millimeters	Mount "C" Inches	Mount "C" Millimeters
W	0.625	15.88	1.000	25.40
X	0.115	2.92	0.160	4.06
Y	0.484	12.29	0.690	17.53
Z	1.000	25.40	1.187	30.15

NOTES

1. The values specified for dimension X are the maximums for the lenses; additional length for clearance should be provided in the camera. With some lenses the section of the mount, smaller in diameter than the root of the thread, extends beyond the limit of dimension X towards the plane of best focus. For such lenses, clearance must be established individually.

2. For the lens, dimension Y is the distance from the registering shoulder to the plane of the best overall image. For the camera, dimension Y is the distance from the registering shoulder to the plane that best represents the location of the emulsion on the film in a camera operating normally. The allowable tolerance for dimension Y depends upon the *f*/value of the lens and other variables, and so is not suitable for definite standardization. A tolerance of ± 0.001 in., applied independently to the lens and camera, is suggested as a generally accepted practice.

3. The values given for dimension Z are maximum diameters for the seat on the lenses; the seat on the camera shall provide clearance for these diameters.

Approved January 7, 1960, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

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10 East 40th Street, New York 16, N. Y.

Printed in U.S.A.
ASA₃M160/35

Revision of American Standard

Published here is American Standard PH22.76-1960, Threaded Lens Mounts for 16mm and 8mm Motion-Picture Cameras (revision of PH22.76-1951), which was approved by the American Standards Association on January 7, 1960. This standard does not differ from the proposal published for trial and comment in the February 1959 Journal, where a summary of its development will be found. — *J. Howard Schumacher*, Staff Engineer.

APPENDIXES

(These Appendixes are not a part of American Standard Threaded Lens Mounts for 16mm and 8mm Motion-Picture Cameras, PH22.76-1960, but are included to facilitate its use.)

APPENDIX 1

Past practice has not been entirely consistent so far as dimension X of the "D" mount is concerned. Some existing cameras will not accept a thread longer than 0.115 in.; some lenses have been made with a length of 0.120 or 0.125 in.

APPENDIX 2

If any part of the lens mount has a larger diameter than dimension Z, it should be checked for mechanical interference with the camera on which it is to be used.

Proposed American Standard

Dimensions for Video, Audio and Control Records on 2-in. Video Magnetic Tape

PH22.120

1. Scope

1.1 This standard specifies the locations and dimensions of the video, audio and control records on 2-in. video magnetic tape.

2. Dimensions

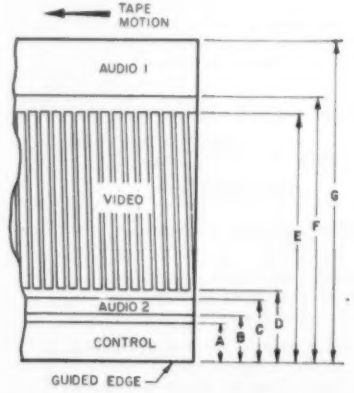
2.1 The dimensions shall be as specified in the diagrams and tables.

3. Magnetic Coating

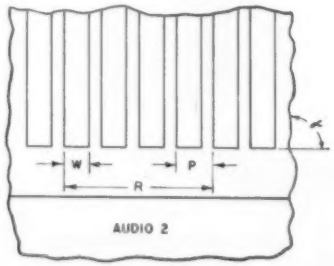
3.1 With the direction of tape motion as shown in the diagram, the magnetic coating is on the surface facing the observer.

4. Video Track Curvature

4.1 The video track shall not deviate from a straight line by more than 0.001 in.



DETAIL OF VIDEO TRACKS



Dimensions	Inches		Millimeters	
	Min	Max	Min	Max
A	0.045	0.050	1.14	1.27
B	0.055	0.060	1.40	1.52
C	0.075	0.080	1.90	2.03
D	0.085	0.090	2.16	2.29
E	1.905	1.910	48.39	48.51
F	1.925	1.930	48.90	49.02
G	1.996	2.000	50.70	50.80

Dimensions*	Inches		Millimeters	
	Min	Max	Min	Max
P	0.0155	0.0157	0.394	0.399
R	0.0620	0.0630	1.575	1.600
W	0.0100	0.0105	0.254	0.267
α	90° 33′ ± 1′			

* These dimensions are based on a nominal tape speed of 15 in./sec and a video-track rate of 960 video tracks/sec.

NOT APPROVED

Proposed American Standard

Characteristics of the Audio Records for 2-in. Video Magnetic Tape Recordings

PH22.121

1. Scope

1.1 This standard pertains to the audio records for 2-in. video magnetic tape recordings.

2. Mechanical Characteristics

2.1 The tape path distance between video and audio recording heads shall be 9.250 ± 0.100 in., with the audio record on the tape preceding the corresponding picture record. The distance between the two heads shall be taken as that between the point of intersection of transverse and longitudinal center lines of each magnetic gap, with the video head positioned at the angle of rotation which places it at the center of the audio track.

3. Electrical Characteristics

3.1 Reproducing characteristics shall correspond to the National Association of Broadcasters Recording and Reproducing Standards for Mechanical, Magnetic, and Optical Recording and Reproducing; Section 2.80, Standard Reproducing Characteristic.

NOT APPROVED

Proposed American Standards

Proposed American Standards Dimensions for Video, Audio and Control Records on 2-in. Video Magnetic Tape, PH22.120, and Characteristics of the Audio Records for 2-in. Video Magnetic Tape Recordings, PH22.121, have been approved by the Video Tape Recording and Standards Committees. The standards are published here for a three-month period of trial and criticism. All comments should be addressed to Society Headquarters, attention of J. Howard Schumacher, Staff Engineer, prior to May 15, 1960. If no adverse comments are received, the proposals will then be submitted to ASA Sectional Committee PH22 for further processing as American Standards.—*J.H.S.*

Correction

In the Proposed American Standard Dimensions for 2-in. Video Magnetic Tape Reels, PH22.116, published in the November 1959 *Journal*, p. 770, a decimal point was missing from the engraving plate. The dimension shown in Table I for G should have read "120 ± 0.1."

EXHIBIT

LOS ANGELES CONVENTION

SEE *the latest in VIDEO TAPE (in actual operation!) — CLOSED-CIRCUIT TV — CAMERAS — PROJECTORS — INSTRUMENTATION AND HIGH-SPEED PHOTOGRAPHY — STUDIO LIGHTING — PRINTERS — PROCESSORS — EDITING AND LAB TEST EQUIPMENT —*

— everything for the motion-picture and television industries.

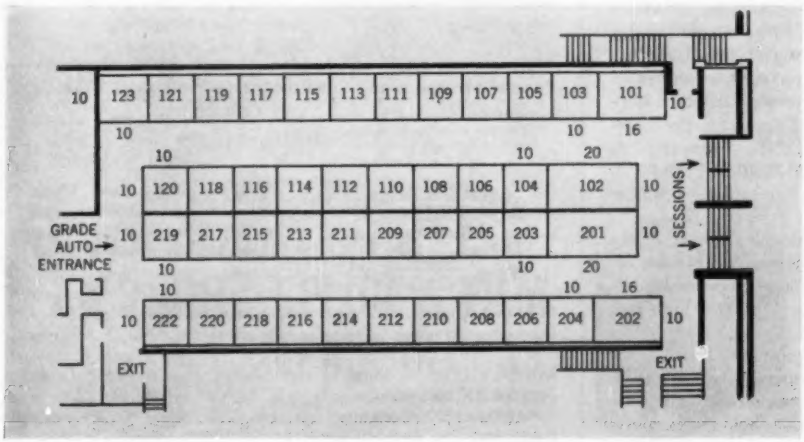


EXHIBIT SPACE RENTAL RATES

Booth No.	Rate	Booth No.	Rate
101	$400	203, 204	$350
102	500	205	300
103, 104	350	206	350
105-109	300	207, 208	300
110-115	290	209	290
116-119	275	210	300
120	300	211-216	290
121	275	217, 218	275
123	300	219	300
201	500	220	275
202	400	222	300

RESERVATIONS *for booth space are now being made by the Exhibit Committee Chairman: Harry Teitelbaum, Hollywood Film Co., 956 N. Seward St., Hollywood 38, Calif.*

87th SMPTE Semiannual Convention

Ambassador Hotel, Los Angeles

EXHIBIT OPEN MAY 2 thru 5

87th Convention and Equipment Exhibit, May 1–7, Los Angeles

Convention Theme: New Techniques for Films, Television and Video Tapes

The Papers Program is shaping up to one of the most exciting of recent years with the complications of the last-minute rush before deadline (an occupational hazard of program chairmen, according to Program Chairman Herbert E. Farmer) more than compensated for by the excellence of the papers.

The Advance Program will be published in the next (*March*) issue of the *Journal*.

A random sampling of recent arrivals to indicate the general level and scope of the Papers Program includes "The New Video-Tape Recorder Toshiba System." Dr. Norikasu Sawazaki of the Tokyo Shibaura Electric Co. is coming to Los Angeles to present this paper which describes a video-tape recorder employing a single rotating head instead of the usual four heads. One of the most significant developments of recent years, Thermoplastic Recording, will be described by William E. Glenn of General Electric Co. A paper by Rudolf Kingslake on "The Design of Zoom Lenses" will survey the development of zoom lenses over the last ten years, leading to contemporary designs.

Another topic of wide general interest will be explored in a paper on "Fiber Optics — A New Tool in Electronics," by Leo J. Krolak, Robert G. Neuhauser and Walter P. Siegmund of Radio Corp. of America. A paper of considerable interest to the nontheatrical field will be "The Kodak Sound 8" by Robert J. Roman, John M. Moriarty and Robert B. Johnson. Educational television will be well represented, one of the outstanding papers being "A Closed-Circuit Television System for Centralized Audio-Visual Projection" by Rudy Bretz of UCLA. Film recording will be discussed in a paper by Meier Sadowsky, "Cathode-Ray Tube and Photographic Film Characteristics as Affecting Film Recording of Television."

Quite a substantial group of papers on various phases of magnetic recording will be presented, among them, "Inter-synchronization of Television Magnetic-Tape Recorders" by Harold V. Clark and Donald B. MacLeod of Ampex; "A Progress Report on Video-Tape Standardization," and "A New Look at High-Frequency Magnetic Recording," both by Charles E. Anderson of Ampex.

This "random sampling" cannot, of course, give a really adequate idea of the scope and significance of the entire program. It is intended only to give the barest preview of next month's Advance Program which, in turn, will preview the 87th Convention.

The Postal Announcement which will be mailed to all members in early March will contain the prospective arrangement of subjects and sessions and the Hotel Reservation Card. For the benefit of members who wish to make their reservations early the rate schedule is given below for the Ambassador Hotel, 3400 Wilshire Blvd., Los Angeles 5. If the Hotel Reservation Card included with the Postal Announcement is not used it would be advisable to mention the SMPTE 87th Convention when making reservations.

Rooms and Suites in the Main Building, per day

Single room:
$9.00, $13.00, $15.00, $17.00, $19.00, $21.00, $23.00

Double room:
$12.00, $17.00, $19.00, $21.00, $23.00, $25.00, $27.00

Parlor Suite occupied by one person:
$30.00, $32.00, $34.00, $36.00, $38.00, $40.00, $42.00, $48.00

Parlor Suite occupied by two persons (one bedroom):
$34.00, $36.00, $38.00, $40.00, $42.00, $44.00, $46.00, $52.00

Garden Studios, per day

Single room: $19.00, $21.00, $23.00, $25.00, $27.00
Double room: $23.00, $25.00, $27.00, $29.00, $31.00

Room with private sun deck or terrace

Single: $23.00, $27.00, $29.00
Double: $27.00, $31.00, $33.00

Living room and bedroom

Single: $46.00, $48.00, with private sun deck $56.00
Double: $50.00, $52.00, with private sun deck, $60.00

Equipment Exhibit:

The word from Harry Teitelbaum, Exhibit Chairman, is that this will be a sensational display by anyone's standards. Millions of dollars' worth of outstanding equipment are being lined up, ranging from a full-scale studio video-tape installation in operation all the way down to the smallest components. An SMPTE Convention is the only place where you can see a comprehensive display of all the latest developments in motion-picture, television, laboratory and instrumentation equipment, conveniently assembled in one place.

The Exhibit will be held, as in past years, in the Sunset Room, adjacent to the sessions auditorium. Details will be found in the announcement on p. 121 of this *Journal*. Anyone interested in taking space should contact Harry Teitelbaum, Hollywood Film Co., 956 N. Seward St., Hollywood 38, without delay.

The traditional Coffee Shop, open all week during the Convention, will be sponsored this time by the Hollywood Film Company, courtesy of Ben and Harry Teitelbaum.

Reports from 5th Congress Delegates and authors representing 15 countries show as many as 85 papers tentatively planned for presentation. Subject matter of the papers ranges over the entire field of high-speed photography. Various research and development projects now underway in laboratories and institutes throughout the world will be described. New equipments and techniques will be related to some of the most daring advances in space exploration and missile research. Other papers will deal with industrial applications and with time-and-motion studies in various fields. Many papers will have wide general interest for the layman as well as the scientist. Among these will be papers dealing with medical and surgical applications.

The 1960 Directory for Members will be published as Part II of the April 1960 *Journal* and is planned to have the same general content and arrangement as the 1958 Directory. If your address is incorrectly listed in the 1958 Directory (April 1958 *Journal* Part II) or has been published incorrectly in the New Members listing during 1959 (Jan., 52–56; Apr., 268–274; Aug., 556–562; Dec. 860–863), please inform us as soon as possible. Also, please look at the label on the envelope in which this *Journal* came to you. There may be an error or inconsistency in the address which we should know about. Suggestions for improving the Directory will be welcome at any time.—*Ed.*

World-Famous Suppliers Of Professional Movie Equipment, Stocking Thousands Of Items

F&B

Serving the World's Finest Film Makers

F & B Solicits Your Bid Requests. None Too Big... None Too Small. Lowest Possible Prices For Top Quality And Service.

FIRST & BEST

Triplex TRIPLE-DUTY

Animation, Titlestand and Product Stage for all Film Makers & Filmstrip Producers

Basic Stand $995

Complete as shown $1595

IN HORIZONTAL POSITION for zoom titles, copy and product and puppet stages.

IN DIAGONAL POSITION Columns can be locked at any angle between horiz. and vert. — for angular zooms-in on table which is locked in horiz. position.

Now You Can Add Animation To Your Lowest Budget Films!

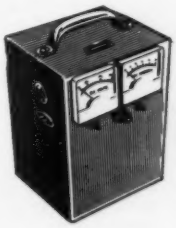
Use the TRIPLEX in vertical position for all standard animation techniques. For filmstrips, stand can be used in all positions. Table can be swung away for large artwork copying. The TRIPLEX stand complete with camera, is also available for rental.

Also available — Cartoon Colours, Punched Acetate Cells and Animation Supplies.

F&B Power-Mite

TRANSISTORIZED POWER SUPPLY

Delivers 100 Watts, 60 Cycles AC



5" x 6" x 9"

$295

Contains:

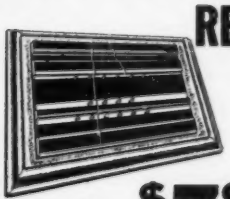
- **15 Volt Power-Mite Battery**
- **Transistorized Converter**
- **Battery Charger**
- **Attached Voltmeter**
- **Charging Rate Ammeter**
- **Metal Case with Leather Carrying Strap and Receptacle**

The days of the gasoline generator are rapidly waning. These tiny transistorized converters and nickel-cadmium batteries are logical successors to unwieldy, unsafe, unreliable and noisy generators. This little 5"x6"x9" unit, weighing less than 12 lbs., will run the 1200 ft. Auricon more than 2,000 feet at 24 fps . . . or it will run the Auricon Super 1200 and the Hallen 16 mm. Recorder **in perfect sync.**

250 Watt Unit Available Soon

Closing Out • Closing Out

F&B BUTT SPLICE & FILM REPAIR BLOCKS



These excellent blocks make butt splicing and repairing damaged film strips simple as A-B-C. Easy to use, no complicated parts, and solidly constructed.

Closing Out This Model at $7.95

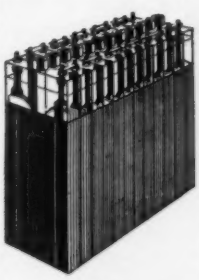
Original Price . . $19.95

Magic "Mylar"

Transparent—For Film

	per roll
16mm.—Single Perf.	$8.00
16mm.—Double Perf.	8.00
35mm.	11.00

This amazing sprocketed splicing tape will repair torn and damaged films, replace torn perforations and allow you to butt-splice without losing a single frame. Splice will never come apart and perforations stay permanently repaired with Magic "Mylar."



NEW F & B POWER-MITE NICKEL CADMIUM BATTERIES

LARGEST CAPACITY — 6-10 amp. hours.
SMALL-LIGHT — 6 oz. per 1.25 v. cell.
INDESTRUCTIBLE — Can be stored indefinitely in any condition.

SAFE — No Acid Spray or corrosion.
CHARGES EASILY — To 90% in 20 minutes, and 100% 30 minutes.

RETAINS 70% CHARGE — After 1 year's storage.

ADD WATER — only a few drops ONCE A YEAR. PERMANENT ELECTROLYTE — 30% solution of Potassium Hydroxide Batteries supplied in metal case with leather carrying strap and plug.

7½ Volt — Power-Mite battery (6 cells) .....$ 85.00
15 Volt — Power-Mite battery (12 cells) $135.00
Attached voltmeter — optional .....$ 20.00
Battery Charger $29.50 Charging Rate Ammeter $10.00

F & B's Power-Mite batteries can be supplied in any combination to power practically all cameras, recorders, etc. All the features listed are absolutely guaranteed by F & B. The Power-Mite nickel cadmium battery is unconditionally guaranteed for one full year.

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Education, Industry News

Herbert T. Kalmus, who founded Technicolor in 1917, retired January 1, 1960, from the offices of President and General Manager of Technicolor, Inc., and Technicolor Corp. Spanning 43 years of motion-picture development, Technicolor has grown from a laboratory built within a railway car to a multi-million-dollar organization. The first Technicolor feature, *The Gulf Between*, was filmed in Jacksonville, Fla., after the rolling laboratory had traveled by rail from Boston. Among the early pictures filmed in this process was the first (1924) *Ben Hur*.

In announcing his retirement, Dr. Kalmus said that he planned to remain with both organizations in the capacity of consultant. He is succeeded by John R. Clark, Jr., Executive Vice-President of the Technicolor companies.

Dr. Kalmus was made an Honorary Member of the Society on October 1, 1958. In his acceptance, he recounted some of the highlights of the history of Technicolor. He described its development as an adventure and defined an adventure as "a remarkable experience usually accompanied with some risks." (*Journal*, p. 829, Dec. 1958)

His successor, Mr. Clark, has been with Technicolor for 24 years, beginning his career as an employee in the manufacturing and research departments. In accepting the post of President, Mr. Clark indicated that present plans included the expanding of the company's operations to new products and services, not only in the photographic field but also in other areas such as audio-visual communication and certain activities in the field of electronics.

A success story with considerable interest for every basement inventor who has withstood the quips and innuendos of less imaginative friends is that of Albert J. Baracket, founder and President of Foto-Video Laboratories, Inc., 36 Commerce Rd., Industrial Village, N.J. Much of the story was reported in the *New York Times* in December. It is unlikely that the traditional shout of "Eureka" ever got shouted, at least by Mr. Baracket, but it is certainly true that inventions that he constructed in the basement of his home have been awarded five government contracts, the most recent being with the Signal Corps for a d-c power supply unit to transform alternating current into both high and low voltage by magnetic and electronic means. One of Mr. Baracket's inventions is a keyed video signal generator that tests the definition of a complete television system — studio, transmitter and receiver. Another device which he developed is a synchronizing generator that keeps a TV camera and the receiver scanning simultaneously.

Mr. Baracket began his career in electronics in 1933 at the age of 21 when he was employed by Radio Corp. of America. Later he completed his college training, receiving the degree of Master of Science in 1949 from the Stevens Institute of Technology. He holds patents on 10 inventions and others are pending. The firm which he founded moved to its present quarters in November 1957.

Awards for films which received special recognition at the 1959 Venice International Film Festival were presented during ceremonies sponsored by the Committee on International Nontheatrical Events (CINE) held in the auditorium of the National Education Assn., Washington, D.C., on December 10. Presentation was made by Gabriele Paresce, Press Counselor of the Italian Embassy. Following presentation of the awards films were shown including an Italian film, *Non Basta sol Tanto l'alfabeto*, winner of the Grand Prix at Venice. American prize-winning films included *Appalachian Spring* by Peter Glushank and Martha Graham; *The Life of the Molds* by Willard van Dyke; *Skyscraper* by Shirley Clark, Willard van Dyke and Irving Jacobi; *Moonbird* by John Hubley, and *My Own Yard to Play In* by Phil Lerner.

Jay E. Gordon, Motion Pictures supervisor for Autonetics, a division of North American Aviation, Inc., has been appointed chairman of the West Coast Subcommittee of the Committee on International Nontheatrical Events (CINE). Members of the subcommittee are: William Barton, Editor, *Film and AV World;* Kirby Grant, TV Sky King; G. Carleton Hunt, President, General Film Laboratories Corp.; Bertha

FILMLINE ANNOUNCES

WORLD'S FASTEST COMMERCIAL PROCESSOR

FOR REVERSAL & NEGATIVE/POSITIVE 16MM FILM

- New impingement-type film Dryer
- Temperature control
- Rinse tank with spraybar after each chemical tank
- Eight film squeegees
- New low-pressure type air squeegee
- Overflows and bottom drains
- Tachometer
- Solution and drybox thermometers
- Oil-less, rotary air compressor with pressure gauge
- Recirculation pumps and spraybars
- Stainless steel, type 316, tanks
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- 1,200 Film Magazine
- Variable Speeds/Development Times

Wherever quality results are demanded in the fastest processing time . . . or wherever illumination is inadequate for quality image density . . . this newest, fastest combination 16MM Reversal and Negative/Positive film processor . . . the Filmline Model RT-S will consistently provide the solutions to these processing problems.

For in-plant, high-speed photography . . . for television stations, racetracks, and motion-picture film labs . . . the Filmline Model RT-S *is the ideal machine* . . . providing quality results at speeds to 125 ft./minute . . . and permitting increases of the ASA index 1000% on DuPont or Eastman Reversal Emulsions.

Fully equipped, ready for immediate operation the Model RT-S offers you high cost film processing features for the low price of only $6,450.00.

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*developing color negatives • additive color printing • reduction printing including A & B • color slide film processing • blowups • internegatives • Kodachrome scene-to-scene color balanced printing • Ektachrome developing and printing • registration printing • **plus complete black and white facilities including cutting rooms, storage rooms and the finest screening facilities in the east.**

Landers, reviewer of nontheatrical films; Richard D. McCann, Asst. Prof. of Cinema, Univ. of Southern Calif.; and Charles A. Palmer, President, Parthenon Pictures Corp. CINE is responsible for selection of American nontheatrical films for showing in foreign film festivals. It also imports foreign nontheatrical films for exhibition to film makers in the United States.

Three appointments made as part of a program of expansion have been announced by Jamieson Film Co. of Dallas, Tex. Jerry Dickinson has been appointed vice-president in charge of television production; Bill Stokes is vice-president in charge of sales; and Robert Redd is vice-president in charge of producer's service.

Col. Robert E. Kearney, who retired from the Air Force December 31, 1959, has been appointed vice-president of the newly created government film division of Filmaster Productions, Inc., of North Hollywood, and general manager of the firm's recently acquired Orlando, Fla., studio facilities. Upon his retirement, Col. Kearney had completed eight years as chief of the Photographic Division of the Photographic and Charting Service of the Air Force.

A. N. Curtiss, of Los Angeles, and **C. E. Dean,** of Little Neck, L.I., N.Y., have been made Fellows of the IRE. They are active members of this Society. The rank of Fellow is the highest membership grade offered by the IRE and is bestowed only by invitation on those who have made outstanding contributions to radio engineering or allied fields. A total of 76 IRE members were advanced to the rank of Fellow as of January 1, 1960, and six awards conferred, including the Founders Award, conferred upon Haradan Pratt, IRE Secretary and consulting engineer. This Award is bestowed only occasionally and for outstanding contributions. Recognition of the Awards will be made by the IRE President during the 1960 International Convention to be held in New York, March 21–24.

R. T. Van Niman is now located in Djakarta, Indonesia, where he is engaged as electronics engineer with the Circarama show. His address: USIS Djakarta, c/o Dept. of State, Washington, D.C., or mail to him may be addressed to the American Embassy, Djakarta, Indonesia.

Paul S. Aex, assistant manager of the Kodak processing laboratory in Palo Alto, Calif., since 1955, has been appointed deputy manager of Eastman Kodak Co.'s processing laboratory in Chicago. He is succeeded by Donald P. Wolz, formerly assistant production supervisor of the film processing division, Kodak Park, Rochester, N.Y. Mr. Aex has been associated with Eastman Kodak Co. since 1939.

William A. Fink has returned to the Atlanta area as district manager for the Audio Products Division of Ampex Professional Products. He has been on leave while acting as marketing consultant for Orr Industries, Opelika, Ala., recently merged with Ampex Corp. In his present post Mr. Fink will be responsible for dealer sales activities of the firm's audio magnetic tape recorders.

Ivar N. Hultman, a vice-president of Eastman Kodak Co. since 1945 and General Manager of Kodak Park Works since 1953, retired January 1, 1960. He is succeeded by Clarence L. A. Wynd, Assistant General Manager of Kodak Park since 1953. Mr. Hultman joined Eastman Kodak Co. in 1919 as a chemist. He later served with Eastman-affiliated companies in New Jersey and Tennessee, returning to Kodak Park in 1927. He was appointed assistant superintendent of the chemical plant in 1930. Following other promotions, he became, in 1942, Assistant General Manager of Kodak Park.

Mr. Wynd joined the company in 1927 as a chemical engineer. He became Assistant General Manager of Kodak Park in 1953 and in 1956 he was elected a vice-president of Eastman Kodak Co.

Recruiting Practice and Procedures — 1959 is a four-page leaflet published by the American Society for Engineering Education which sets forth the rules developed by ASEE and endorsed by the Ethics Committee of the Engineering Council for Professional Development for the guidance of employer, college placement bureaus and students, and to aid in the development and maintenance of high ethical standards in the procedures of college recruiting. The leaflet is priced

HIGH-SPEED HEAD

Supplied to fit existing B&H Contact Printers Model D (35mm) or J (16mm) in your own shop

Size: 15" x 15" x 12"

Continuous Black-and-White Printing at 200 ft. per minute

This compact high-speed head uses a single light source. Lamphouse is designed for a 1000-Watt T-12 bulb with blower. Bulb alignment easily made in darkness by adjusting three knobs, providing for vertical, transverse and rotational motion of the bulb.

One electro-mechanically operated light valve provides changes in 6 milli-seconds which show as a scene change flash of ⅓ of a frame. The light valve is controlled by 5 small solenoids to provide 32 printer steps of .025 or .030 Log E. Light valve opening may be adjusted to compensate for stock changes without altering the 32-step arrangement. Head can also be used for color printing with balanced inter-colored negative.

Optical system, contained in the casting, provides uniform light on the aperture of the B&H transport. Due to a cold mirror of the effective interference type, very little heat reaches the printing aperture. Heat absorbing glass is eliminated.

No skilled technician is required to operate the head. Entire programming of scene-to-scene changes, including start, stop and lap dissolves, is automatically accomplished by the use of an 8-hole punched tape reader and memory unit. This one-channel memory unit, with reader for automatic operation of the light valve, stores the introduced information, using an 8-hole punched tape reader. It permits the printing of scene changes as small as 3 inches in length and storing of 32 printer steps plus start, stop and lap dissolves. For easy servicing, commercially available 8-hole punched tape reader is used as a base.

AUTOMATIC OPERATION

Standard punched-tape units have been recorded and modified to bring about automatic operations of film printing equipment. Punched tape performs the functions of discrete scene-to-scene light changes, dissolves shutter operation and automatic stopping equipment, adjusts light level and printer characteristics for any particular job. Complex printer operations may be performed with great accuracy at high speeds.

•

Write for further information

•

Head with lamphouse and blower, ready for mounting to the B&H pedestal and transport Model D or J..... $5,500

One-channel memory unit with reader..... $1,650

All prices F.O.B. New Rochelle, N.Y.

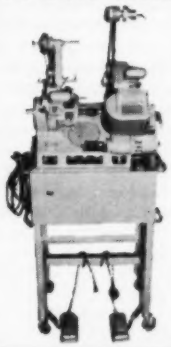
FISH-SCHURMAN CORPORATION, 85 Portman Road, New Rochelle, N. Y.

PUZZLED ABOUT EDITING MULTIPLE SOUND TRACKS?

IF SO THEN TRY THE **NEW**

CAMART ADD-A-UNIT EXTENSION PLATE

From this



For Series 20 Moviola — U. S. Pat. Pending

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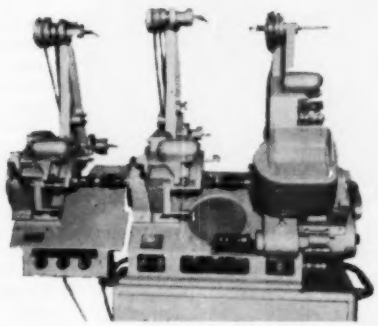

Here's How It Works!

Today when you have a completed feature or short a Musical score is recorded to suit. Each recording for effects background is done on separate tracks. Here is where the Camart Add-A-Unit can save you time and money. With the Add-A-Unit you can edit and cut three or more tracks simultaneously. No need to go back again and run the whole picture through. Everything is done in one operation.

HERE'S WHAT YOU GET:

1. The Add-A-Unit extension plate ribbed construction of durable aluminum alloy, precision machined to fit any series 20 Moviola film editing machine in perfect alignment.
2. Extra belt guards and screws.
3. Complete flexible coupling assembly to interlock sound heads.
4. Extra flange.
5. Amplifier connections with all ready made fittings for easy installation.
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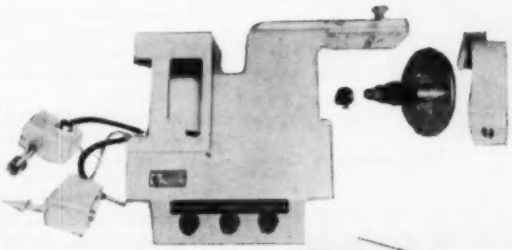

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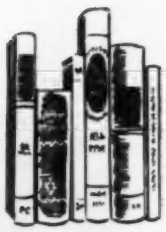
The Daniel and Florence Guggenheim Foundation, 120 Broadway, New York 5, which annually grants Fellowships for studies in Jet Propulsion at Princeton and the California Institute of Technology, and in Flight Structure at Columbia University, has announced that applicants should file their credentials with the University of choice by March 1, 1960. Up to 18 Fellowships are awarded annually to qualified science or engineering students who are prepared for graduate study and who have outstanding technical ability and qualities of leadership; deep interest in rockets, jet propulsion, flight structure or astronautics, and an intention to follow one of these fields as a career. Applicants must reside in the United States or Canada.

Biographical Note

Edwin C. Fritts

Dr. Fritts retired on January 1, 1960, after being associated with Eastman Kodak Co. for 37 years. At the time of his retirement he was supervisory physicist in the apparatus research and development department of Eastman Kodak Co. Prior to his joining Eastman Kodak in 1923 —the same year in which he received the degree of PhD. in Physics from the University of Illinois — he had been employed on a part-time basis during the summers of 1920 and 1921. In 1920 he invented the Kodak Autofocus Enlarger, one of the first amateur automatic focusing enlargers.

Recently Dr. Fritts has been associated with the development of the Eastman 16mm Projector, Model 25, and its counterparts for television use, Models 250 and 275. Since 1953 he has worked on various problems related to television and aerial photography. Earlier, he developed special apparatus, particularly for Cine-Kodak processing, and in cooperation with the Research Laboratories, he developed the Sound Kodascope Special. A Fellow of this Society, he has served for several years on the Television Committee and has published a number of papers in the *Journal*. One of his more recent papers is "A 16mm Projector for Operation With TV Film-Chain on Partial Storage Basis," (*Journal*, pp. 567–577, Oct. 1955). He is a member of Sigma Xi (honorary scientific fraternity), Photographic Society of America, and the Rochester Section of the American Optical Society.



books reviewed

Principles of Cinematography, 2d ed.

By Leslie J. Wheeler. Published (1958) by Fountain Press, 46–47 Chancery Lane, London W.C. 2. 472 pp. Illus. Published in the U.S. (1959) by Macmillan Co., 60 Fifth Ave., New York 11. Price $12.75.

This book is a second edition of the book published in 1953. The publisher's jacket comments that, "The author explains in a wealth of detail all the processes and equipment used in present-day motion picture production and exhibition," and "The work comes right up to date." However, careful examination of the 1958 edition shows it to be an exact duplicate of the 1953 edition in all sections with no revisions or inclusions of the many recent developments. Faster black-and-white films of four years ago are not included, and color photography is excluded completely along with wide-screen and anamorphic systems.

The chapters covering General Photographic Principles, Cameras, Processing Equipment, Printing, Projection, Sound Recording, etc., are started with excellent historical and technological background material on each subject. The volume is well written and illustrated and contains a good bibliography although it has no recent reference additions.

The book provides an excellent reference for most phases of the technology and history of cinematography until ten years ago and would be a valuable source book for the library of anyone in the field.—*Earl W. Kage*, Eastman Kodak Co., Research Laboratories, Rochester 4, N.Y.

Kinotechnische Bücherei: Bildtechnik, by Helmuth Schering; **Elektrotechnik,** by Fritz Trommer; **Tontechnik,** by Fritz Trommer; **Vorführgerätetechnik I,** by A. R. Schulze; **Vorführgerätetechnik II.** by Gerhard Pierschel; **Störungsdienst-Kontrolle und Wartung,** by A. R. Schulze.

Ed. A. R. Schulze. Published (1959) by Fotokinoverlag, Halle (Saale), Germany. Paper covered. Approx. 70 pp. each. Illus. 5¾ by 8 in. Prices DM 3.30 ($0.79), 4.80 ($1.15), 4.80 ($1.15), 4.60 ($1.10), 4.80 ($1.15), 4.60 ($1.10).

These six German booklets are part of a useful set of 14 motion-picture booklets issued by Fotokino Publishing Company in Halle, (East) Germany. The other eight publications are titled as follows: *Lichttechnik* (Lighting Technique); *Projektions-*

technik (The Technique of Projection); *Lichtton-und Magnettontechnik* (Optical and Magnetic Sound Technique); *Verstärkertechnik* (Amplifier Technique); *Bildwerferraum* (The Projection Room); *Akustik* (Acoustics); *Zuschauerraum* (The Auditorium); *Stromversorgung* (The Electric Supply). They provide a quick and convenient reference to each of the subjects.

The price appears to be low, about $0.80 to $1.15. The 6 by 8-in. soft-bound size is a handy format for this type of publication. Each contains a subject index which appears to be more complete in some of the booklets than in others.

Bildtechnik (Picture Technique) by Helmuth Schering. (48 pp., 17 illus., 6 tables)

This booklet discusses the factors which influence the viewing of the projected image: the dimensional proportions of the image; the optical conditions; the kind of illumination; and the projector. With the introduction of the "wide screen" the movies are attempting to show a picture which simulates to a large extent the impression of reality. How this is achieved, which conditions have to be maintained and which shortcomings still remain in the projection, are discussed in the first part. In the second part the different projection schemes are compared: also the current existing image and film sizes are discussed. All ideas are treated from the projectionist's viewpoint. Some of the ideas are further developed in the booklets, *The Projection Technique* and *Lighting Technique*.

Elektrotechnik (Electrical Technique) by Fritz Trommer. (80 pp., 37 illus.)

The basic principles of electrical and magnetic techniques are discussed in this booklet, as it is necessary for the technician to understand how sound is reproduced in motion-picture theaters. Because of space limitations a detailed explanation of the physical theories was not always possible. Instead, on many subjects only the important facts are given.

Tontechnik (Sound Technique) by Fritz Trommer. (71 pp. 36 illus.). This booklet is intended for the projectionist and for the inspector, to furnish basic knowledge on servicing the entire sound system of motion-picture theaters. The information contained in this booklet is needed to understand optical and magnetic sound as applied to motion-picture theaters. Only the facts, without the detailed theoretical explanations, are given. The subject matter can be considered as the continuation of the booklet on electrical technique. The knowledge of its contents is presupposed. The emphasis is on detailed description of occurrences in a-c circuits for electroacoustics and treatment of basic principles of electroacoustical transmittance as it occurs in theaters. The important construction elements needed to transmit sound are also discussed.

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Vorführgerätetechnik I (Technique of Presentation — I Stationary Projectors) by A. R. Schulze. (64 pp., 55 illus., 6 tables).

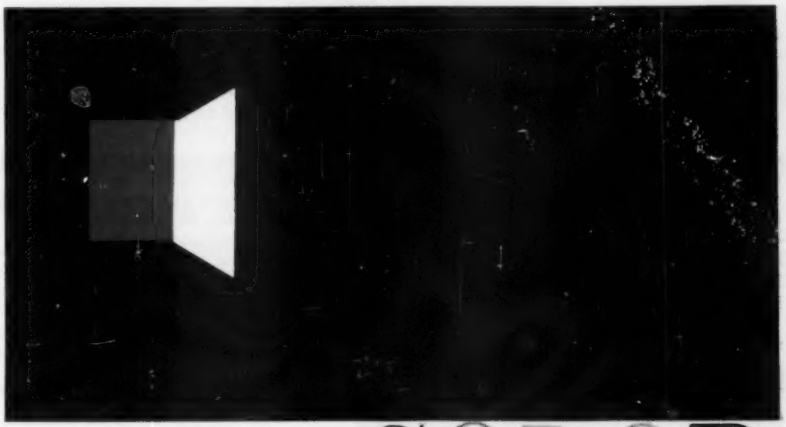
Stationary projectors for 35mm and 16mm film made by Askania Berlin, Eugen Bauer-Stuttgart, VEB Kinowerke-Dresden, Zeiss Ikon-Stuttgart, Frieseke and Hoepfner-Erlangen, German Philips-Hamburg are discussed. Film base, film dimensions, perforation types and film spools are treated briefly. Specifications for projectors, circuit load requirements and circuit designs are enclosed.

Vorführgerätetechnik II (Technique of Presentation — II Portable Instruments) by Gerhard Pierschel. (70 pp., 43 illus., 2 tables).

The projectors discussed are Sonolux T10 Bauer-Stuttgart, FP3 by German Philips-Hamburg, TK35 and TK16 by GEB Carl Zeiss-Zena, P8 Weimar by VEB Precision Instrument Works-Weimar. General arrangement of subject matter is somewhat similar to that of Part I.

Störungsdienst — Kontrolle und Wartung (Servicing of Troubles — Supervision and Maintenance) by Alfred Schulze. (72 pp., 13 illus.)

In well-organized tables, the test methods, test instruments (as used in East Germany), frequency of inspection, and list of spare parts are given. The contents are valid for 35mm, 16mm and 18mm equipment. This compilation of the possible troubles, their causes and remedies



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should be of particular interest to professional or amateur projectionists.—*E. I. Guttman*, Eastman Kodak Company, Kodak Park, Bldg. 35, Rochester 4, N.Y.

Film-Licht-Farbe:

Ein Handbuch für Kameraleute

By Hilmar Mehnert. Published (1959) by Fotokinoverlag, Halle (Saale), Germany. 252 pp. 85 illus. tables 5½ by 8 in. Price DM 25.80 (about $6.50).

This book is intended for the professional photographer or serious amateur. It is concerned exclusively with matters of film and photographic technique. As the author states, it is not a textbook but rather a reference work which provides concise answers to many specific questions.

The first part is 50 pages of tables and graphs having to do with sensitometry and light control. This should satisfy some of the experts, but the last part is a 200-page dictionary of phototechnology especially for the benefit of less sophisticated workers. Described here are the German equivalents of such terms as additive color mixture, back light, Callier coefficient, diopter, exposure index, etc. The book then ends with a 3-page English glossary of relevant light and color terms. A number of helpful line drawings and several interesting photographic illustrations are included.

This compact compilation is a valuable source of technical information for German "camera people" both professional and amateur. Were it not for the language difficulty, many Americans would also consult it.—*Sidney M. Newhall*, Eastman Kodak Co., Color Technology Div., Rochester 4, N.Y.

Tape Recorder Manual, Vol. 5, published by Howard W. Sams, Inc., 1720 E. 38 St., Indianapolis 6, Ind., is a service manual (160 pp., 8½ by 11-in.) presenting detailed information on popular brand tape recorders, including assembly and disassembly details. It is priced at $2.95 and is available from electronics parts distributors. Another recent publication is *101 Ways to Use Your Audio Test Equipment* by Robert G. Middleton. This is an addition to the series, "101 Ways Test Equipment Library." The book contains 144 pages, measures 5½ by 8¼ in., and is priced at $2.00. It may be ordered from the publisher by specifying catalog number TEM-5 and is also available from electronic parts distributors.

Compilation of Standards on Electrical Insulating Materials D-9 is published by the American Society for Testing Materials, 1916 Race St., Philadelphia 3. This edition (792 pp, 6 by 9-in., priced at $8.75) contains 108 standards of which 46 are new, revised or have had their status changed since the previous edition was published in 1957.

current literature

The Editors present for convenient reference a list of articles dealing with subjects cognate to motion-picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D.C., or from the New York Public Library, New York, N.Y., at prevailing rates.

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Fog Maker (p. 606)

Clouds Made to Order (p. 611) *C. G. Clarke*

A Black-&-White Traveling Matte Process (p. 612) *R. L. Hoult*

Importance of "Reference White" in Films for TV (p. 614) *J. Stott*

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Simplifying the Sync Problem (p. 620) *J. D. Jones*

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New Fast Reversal Color Film (p. 660)

Seven Screens for Moscow (p. 670) *H. A. Lightman*

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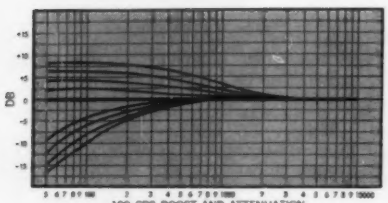

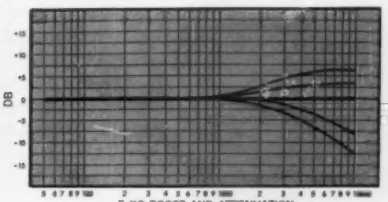

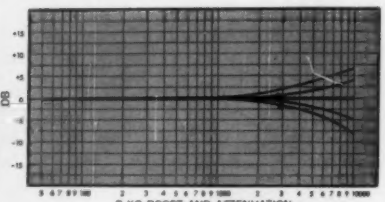

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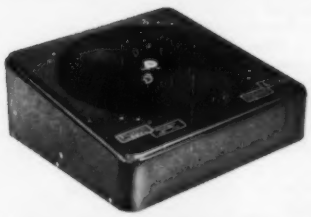

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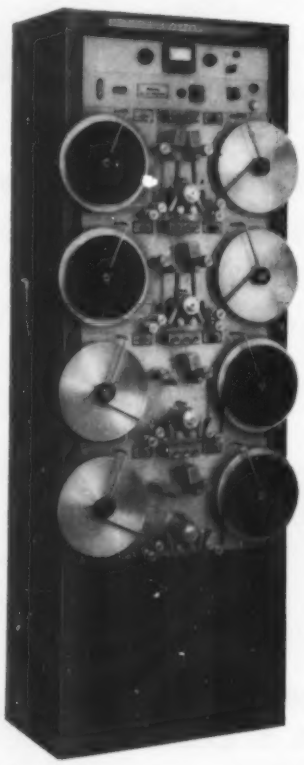
Magnetic Recording of Color Television (p. 76) *J. Roizen*



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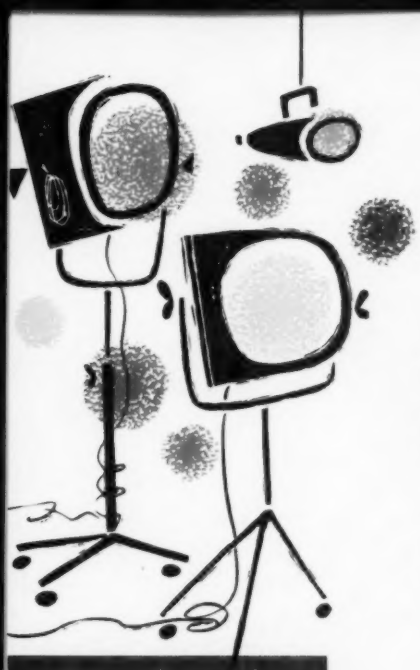

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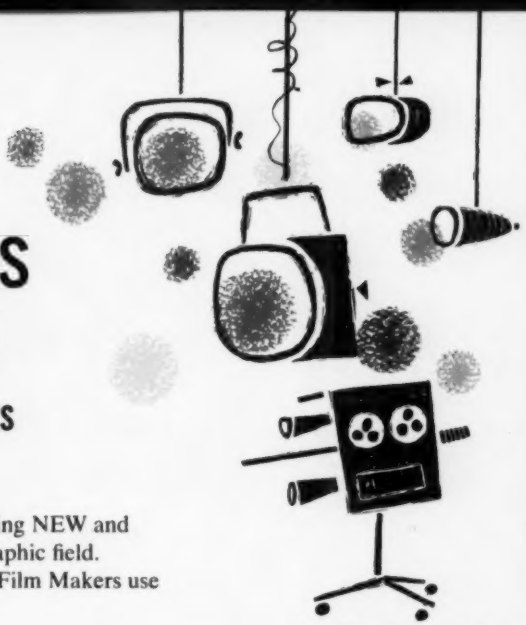

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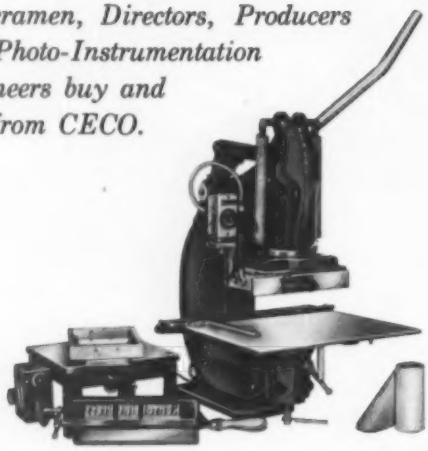

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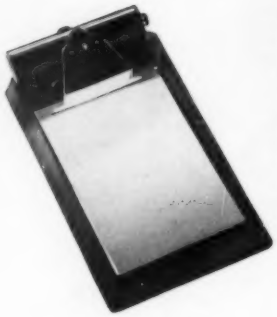

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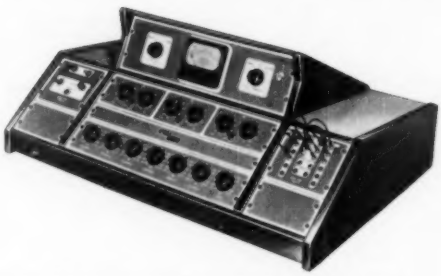

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Abstracts

Abstracts from other Journals, chosen for importance and timeliness, are published in the *Journal* from time to time. The greater number of these abstracts are translations, chiefly from the U.S.S.R., and made available by the *Kodak Monthly Abstract Bulletin*.

CAMERAS AND EXPOSURE

The Krugorama Motion-Picture Camera

The Krugorama camera is intended for taking films for the new circular panoramic motion-picture theater. It consists essentially of eleven synchronized 35 mm. motion-picture cameras arranged in a circle. (S. C. G.)—O. V. Peschanskii *Tekh. Kino i Televideniya*, pp. 58–60, June 1959.

COLOR PHOTOGRAPHY

A Method of Practical Testing of Color Negative Films

To supplement the usual sensitometric tests carried out in production, a practical test of color negative films is suggested in which a standard test-object, made up from colored objects in a three-dimensional arrangement, is filmed under standard lighting conditions. A positive film is printed from the developed negative and is inspected. Exposure and processing are carefully controlled. (S. C. G.)—I. B. Gordilchuk. *Tekh. Kino i Televideniya*, pp. 60–67, June 1959.

The Law of the Change of Rate of Color Development With Change in the Properties and Increase of Concentration of Nondiffusing Color Couplers in a Photographic Material. I. The Relation Between the Coefficient of Contrast of a Color Image and the Log Concentration of the Nondiffusing Coupler

A number of considerations lead one to expect the contrast coefficient of the dye image produced by color development to be proportional to the logarithm of the concentration of the color coupler. To test this, a study was made of the dependence of γ on coupler concentration for a high-speed color emulsion, without optical sensitizers, containing different couplers, derivatives of 1,2-hydroxynaphthoic acid, of pyrazol-5-one, and of acylacetic acids, forming cyan, magenta, and yellow dyes, respectively. The linear relationship between γ and log concentration was confirmed for all the couplers studied over the concentration range used, 2 to 16 g per liter of emulsion. (S. C. G.)—V. I. Uspenskii and I. I. Rodionova. *Zhur. Nauch. i Priklad. Fotografii i Kinematografii*, 4:285–88, No. 4, July-Aug. 1959.

HIGH SPEED PHOTOGRAPHY

A Rotating Mirror Camera

A convenient rotating-mirror camera has been devised as an auxiliary to an ammonium dihydrogen phosphate (ADP) Kerr-effect camera. The maximum number of rotations of the rotor is 700 rps., the maximum moving speed of the image on the film is 1 cm per 1.15 microsec., and the superposed time on one frame is about 7 μsec. A diagram of the optical system, and photographs taken with the camera are reproduced. (Author's Abstract)—Y. Wachi. *J. Appl. Physics, Japan*, 28:96–103, No. 2, 1959. (In Japanese, with a table and captions to the figures in English.)

The New "VFK" High-Speed Camera

A description is given of the principles and construction of a high-speed camera with a taking rate of 6000 to 42,000 frames/sec. A strip of film is placed inside an evenly rotating drum. Inside this drum is a second drum rotating around the same axis but at a different speed. On the periphery of the internal drum are placed several series of small objectives forming images of the subject on the light-sensitive layer. The small objectives work on the parallel beams, forming a collimating objective, the front focus of which coincides with the plane of the object being photographed. Mathematical consideration is given to the exposure time of individual frames, and also to the degree of optical compensation obtained. (S. C. G.)—[Translated from *Referativnyĭ Zhur., Fiz.*] J. Hampl. *Jemná mech. a opt.*, 3:89–92, No. 3, 1958. (In Czech.)

A Project for a Camera for Continuous Exposure With a Slit Grid. I. The Working Principles of a Slit-Grid Camera

The type of high-speed camera described uses a grid of transparent parallel slits on an opaque background. The grid is placed in front of a moving sensitized plate or film and several consecutive line images are recorded in the one frame, with sacrifice of detail. The individual images may be reconstituted by projecting the print through the original grid to give either separate pictures or a motion-picture film. The taking frequency and length of total ex-

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posure will depend on the ratio of the width of the slit and the distance between slits. Expressions are derived for choosing these magnitudes for a given case. Several possible systems for the relative displacement of image and photographic material are described, and, finally, a description is given of an experimental camera of this type made for a popular science film studio in Moscow. Image displacement is achieved by fixing the film to a rotating disk. Reconstruction of the image can be carried out in the camera itself by means of a special cassette which is attached to the back of the camera in place of the taking cassette. The processed film is mounted on a disk and is viewed through a window, while an image of the grid, illuminated with strong, diffuse light, is projected onto the frame. A film can be made through the viewing window, with a time magnification ratio of approximately 10^3. The camera is specially useful for photographing self-luminous events lasting less than 10^{-4} sec. (S. C. G.)—S. V. Kulagin. *Zhur. Nauch. i Prikład. Fotografii i Kinematografii.* 4: 215-221, No. 3, May-June 1959

PROJECTION

An Experimental Setup for Shutterless Motion-Picture Projection With the Xenon Lamp

A short description is given of an experimental laboratory setup for shutterless motion-picture projection of 16mm films with a 1-kw, a-c xenon lamp giving 1500 lumens of useful light flux on the screen. The requirements of the optical system and the xenon lamp are discussed. The lighting characteristics of samples of xenon lamps developed by the Moscow electric lamp factory, and results obtained with these lamps in motion-picture projectors, are considered. (S. C. G.)—[Translated from *Referativnyĭ Zhur., Fiz.*] G. A. Golostenov. *Trudy Vsesoyuz. Nauch.-Issled. Kinofotoinst.* (Moscow), pp. 140-156. No. 13 (23), 1957.

A 15,000-Lumen Lighting System for a Motion-Picture Projector

The lighting system described for a motion-picture projector gives a light flux of 15,000 lumens. A method of calculation is put forward, and results are given, for some variant spheroelliptical and elliptical reflectors. The advantages of an aspherical glass reflector with a given profile are noted. The necessary light flux is achieved by means of a high-intensity arc with special carbons. The characteristics of Soviet and foreign lighting systems are set out and compared. The 15,000-lumen lighting system corresponds to the best in contemporary motion-picture projectors. (S. C. G.) —[Translated from *Referativnyĭ Zhur., Fiz.*] G. A. Golostenov and A. N. Lazereva. *Trudy Vsesoyuz. Nauch.-Issled. Kinofotoinst.* (Moscow), pp. 60–90, No. 13 (23), 1957.

The Circular Motion-Picture Panorama in Moscow

July, 1959, will see the opening, in Moscow, of a completely circular panoramic motion-picture theater which holds 200 to 250 spectators. The 360-degree panorama is obtained by the projection of eleven films, taken in a special camera, onto eleven screens. A brief description of the theater is given. (S. C. G.)—*Tekh. Kino i Televideniya,* pp. 55–57, June 1959.

The Noiseless Form of the Simple Carbon Arc

The causes of the formation and the specific properties of three forms of the simple carbon arc are considered: the quiet, the hissing, and the noiseless. The operative causes of the tendency to hissing of an arc are clarified. A suggestion is made for a method of controlling the quality of the sheathing of high-intensity carbons for cinematography. The method consists in recording from time to time the electrical characteristics of the arc and the determination of the critical current strength when the sheathing is used as anode.

Examples are given of records of the potential differences of arcs working with anodes in the form of sheaths containing carbon masses of different degrees of purity. (S. C. G.)—[Translation of Authors' Abstract] N. A. Karyakin and N. V. Chernysheva. *Tekh. Kino i Televideniya,* pp. 5–10, July 1959.

SOUND RECORDING AND REPRODUCTION

On the Theory of Linear Magnetic "Traces" of Varying Intensity

It is shown that losses in a magnetic recording and reproducing system with a

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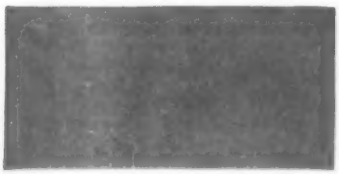

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carrier in the form of a magnetic powder on a dielectric band, which, hitherto, have been classified as losses due to the finite thickness of the magnetic layer of the band, are the result of self-demagnetization of the traces.

Formulas are derived for calculating losses due to the self-demagnetization of a linear trace. (S. C. G.)—[Translation of Author's Abstract] V. A. Geranin. *Tekh. Kino i Televideniya*, pp. 11–16, June 1959.

More on the Question of a Single Technology of Sound Recording for Art Films

The current discussion of the standardization of sound-recording techniques in Soviet studios is continued with a comparison of 35 mm and 17.5 mm films as sound carriers, in which some earlier criticisms brought against the latter are countered. (S. C. G.)—G. A. Korenblyum. *Tekh. Kino i Televideniya*, pp. 20–22, June 1959.

Techniques of Editing and the Dimensions of Synchronized Magnetic Soundtracks

The apparatus described for printing magnetic soundtracks onto positive copies is the subject of a series of Author's Certificates (Soviet Patents) and was elaborated at the Kishinev film studios. It allows for synchronization of both 17.5- and 35-mm magnetic bands, advancement of the magnetic original in either direction, printing of selected portions without cutting the original, and automatic stopping of the magnetic original when the end of the film is reached. (S. C. G.)—S. A. Solov'ev. *Tekh. Kino i Televideniya*, pp. 17–19, June 1959.

OPTICS

The Possibility of Calculating an Achromatic Objective for the Long Wave-Length Part of the Spectrum

It is stated that the relative dispersion of lithium fluoride and fluorite changes within a narrow range (1.9–2.1) in the spectral region from $\lambda = 2\mu$ to $\lambda = 5.5\ \mu$. This makes it possible to calculate an achromatic objective with a small secondary spectrum from these materials. Data are given for one objective calculated in this way, with a focal length of 100 mm. and a relative aperture of $f/5$. (S. C. G.)—[Translated from *Tekh. Kino i Televideniya*] I. V. Pelsakhson. *Optiko-Mekh. Prom.*, p. 13, No. 2, 1959.

SENSITOMETRY

Scientific Discussion on the Sensitometry of Black-and-White and Color Photographic Materials

The papers presented at a discussion held by the Commission for Scientific Photography and Cinematography of the Academy of Sciences, U.S.S.R. (April 21–23, 1959) are abstracted. (S. C. G.)—Yu. N. Gorokhovskii. *Zhur. Nauch. i Priklad. Fotografii i Kinematografii*, 4:317–319, No. 4, July-Aug. 1959.

The International Standardization of a Method of Numerical Expression of the Speed of Black-and-White Negative Materials

The principles on which the Russian, German, and American national sensitometric standards, GOST 2817–50, D. I. N. 4512 (1957 revision), and ASA PH2–5–1954 (= R-6), are based are set out. The main points in the draft of a new international standard, presented by the U.S. delegation to the Harrogate conference, are set out, and the system is explained. It is considered to be a good basis for compromise between the national groups. (S. C. G.)—I. A. Chernyi. *Zhur. Nauch. i Priklad. Fotografii i Kinematografii*, 4:313–316, No. 4, July-Aug. 1959.

IMAGE STRUCTURE

A Study of Factors Influencing the Properties of Polarization Images

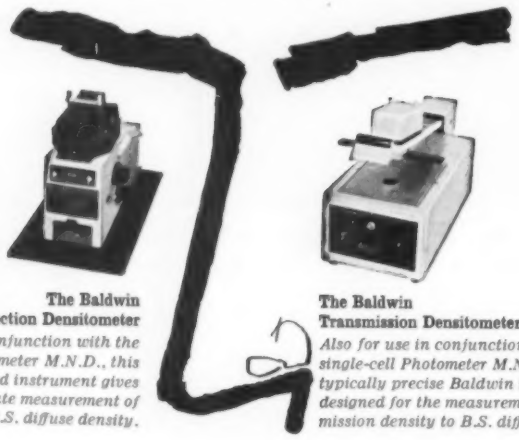
The results of a study of the process of printing polarization images are presented. Consideration is given to the following: densitometry for the measurement of the polarization density; characteristic curves of the silver, relief, and polarization images; the relationship between the change in shape of the polarization characteristic curve and the concentration of iodine in the printing solution; and the relationship between the change of shape of the polarization characteristic curve and the degree of stretching of the film. (S. C. G.)—[Translated from *Tekh. Kino i Televideniya*] S. S. Savko and G. P. Faerman. *Optiko mekhan. prom.*, pp. 13–17, No. 1, 1959.

Detail Quality in Motion-Picture Negatives and Positives

Results are given of comparisons of standard and five types of wide-screen cinematography in regard to the detail quality which can be obtained on a negative frame and on its positive copy. The detail quality is conventionally taken to be equal to the product of the frame area and the square of the resolving power at its center, or of frame area and resolving power in the main direction for anamorphic systems. Resolving power is determined from empirical formulas, taking into account the properties of the negative and positive materials, the focal length of the taking objective, and the degree of enlargement during printing. Calculations have shown that systems using the wider frame size can give positive images with approximately double the detail quality. (S. C. G.)—[Translated from *Referativnyi Zhur., Fiz.*] R. Tiedeken. *Techn. Kinematogr.*, pp. 9–13, No. 9, 1957. (In Polish.)

Studies in the Ability of Photographic Materials to Reproduce Small Elements of an Optical Image. I. A Quantitative Evaluation of the Photographic Reproduction of a Two-Dimensional Subject

A method is proposed for the quantitative evaluation of photographic materials to reproduce, with geometrical correctness, fine two-dimensional detail. The corresponding quantity is named "discriminating power." It was found that basically the rules for discriminating power—the influence of subject contrast, exposure, de-



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velopment time—are similar to the analogous rules for resolving power.

The linear dimensions of detail at the limit of recognition are 2.5 to 3 times greater than the dimensions of a linear grid at the limit of resolvability. The relation between the absolute values of the discriminating and resolving powers differs to some extent for different materials.

The optimal density and exposure for discriminating power are somewhat higher than for resolving power, because of the difference between the optical tasks of the *recognition of shape* and of the *differentiation of lines* in a regular grid. (S. C. G.)—[Translation of Authors' Abstract] Yu. K. Vifanskiĭ and Yu. N. Gorokhovskiĭ. *Zhur. Nauch. i Priklad. Fotografiĭ i Kinematografiĭ*, 4:276–284, No. 4, July-Aug. 1959.

TELEVISION

Electron-Beam Tubes for the Televising of Motion-Picture Films by the Flying-Spot Method

The 18LK8ZL projection tube for the transmission of color and black-and-white films by the flying-spot method is considered. The characteristics of this tube are set out, together with the results of tests of such tubes in a flying-spot system.

Similar information is provided regarding the 18LK13L tube for the transmission of black-and-white films over a black-and-white television system. [Abstractor's Note: The designations refer to Russian tubes.] (S. C. G.)—[Translated from Tekh. Kino i Televideniya] E. V. Vorb'ev and E. I. Zhukovskaya. *Televiz. Elektronika (Trudy OKB)*, pp. 40–53, No. 1, 1959.

A Gating Circuit for Single-Gun Colour Television Tubes

The requirements of an ideal gating circuit for use with single-gun colour television tubes and the limitations of some existing circuits are discussed. A new type of gating circuit which employs low-level gating of the red, green and blue video signals in conjunction with a wideband amplifier is described. Such a circuit is believed to have a performance superior to that of most existing circuits and by fairly simple modification is applicable to either reversing colour sequence, continuous colour sequence or to colour difference operation.—K. G. Freeman, *Jour. Brit I.R.E.*, pp. 667–677, Nov. 1959.

Some Aspects of the Design of a Small Television Station

Some of the factors governing the choice of equipment for use in small commercial television stations in isolated areas are discussed. Specific reference is made to two different types of installation at station ZBM-TV, Bermuda, using the same basic equipment. The two systems described relate to (a) a combined television center containing both studio and transmitter in the same building, and (b) separate studio and transmitter sites. The equipment used included vidicon telecine and studio cameras and a 500w vision transmitter. Details are given of these items and also of vision, sound and control facilities.—Aubrey Harris, *Jour. Brit I.R.E.*, pp. 705–721, Nov. 1959.

section reports

The Chicago Section met on December 16 with an attendance of 45 for a tour of Chicago's Armour Research Foundation. Nelson Rodelius, a photographic engineer with the Armour Research Foundation, was guest speaker at the meeting.

Following the film opener, *The Armour Research Reactor*, produced by Atomics International, the SMPTE group was welcomed by Dr. Christopher Barthel, Assistant Director of Armour Research Foundation. His introduction urged greater SMPTE leadership in developing young people for work in basic research areas.

Mr. Rodelius, who is a member of the SMPTE Chicago Section, presented a paper on "Photography in Research at Armour Research Foundation," which covered the applications and special problems of motion-picture documentation in acoustical, electrical, fluid, heat and mechanical research.

The meeting concluded with a guided tour of Armour's research reactor, Univac 1105 installation, and acoustical laboratory reverberation and anechoic chambers.—William H. Smith, *Secretary-Treasurer*, Lakeside Lab., Box 2408, Gary, Ind.

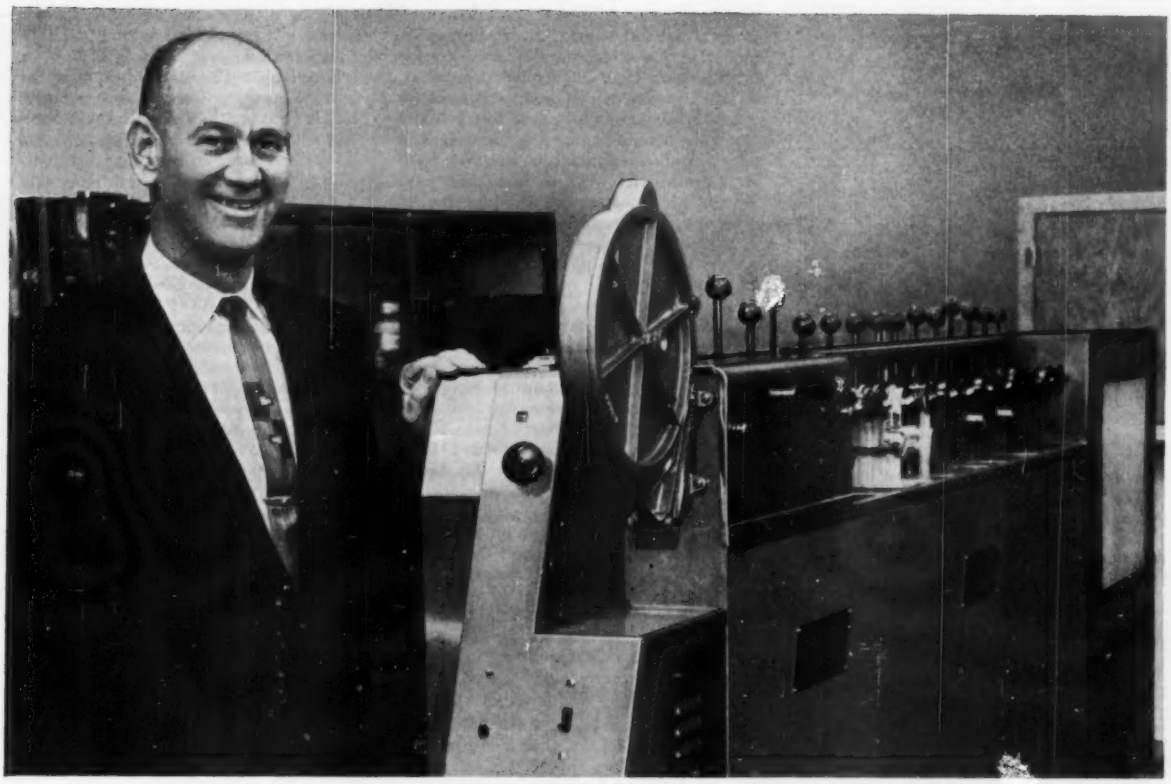
The Chicago Section met on January 20 at the Bell & Howell Co. with an attendance of 72. After a brief welcome by Malcolm G. Townsley, Engineering Vice-President of Bell & Howell, two papers were presented by H. C. Wohlrab of the Bell & Howell technical staff.

In his first paper, Dr. Wohlrab gave a brief history of the development of automation in commercial film printing and a detailed account of the most recent automation in additive color printing. His talk was illustrated with a number of excellent slides, motion-picture shorts and actual equipment demonstration. The height of audio-visual presentation was achieved in demonstrating the actual operation of the automatic printer fully synchronized with a motion-picture short which illustrated in greater detail the functioning of the essential parts of the printer.

Dr. Wohlrab's second paper included a description of the operation of the new Bell & Howell 16mm Continuous Film Printer, Type JM, and an actual illustration of the equipment. Following the meeting, the equipment was available for inspection by the audience.

An intermission followed the first paper during which time coffee and doughnuts were served through the courtesy of the Bell & Howell Co.

Prior to the meeting, a short meeting of the Board of Managers of the Chicago Section was held at the W. J. German offices, 6040 North Pulaski, Chicago.—Philip E. Smith, *Secretary-Treasurer*, Eastman Kodak Co., 1712 South Prairie Ave., Chicago 16, Ill.



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The Hollywood Section met on January 19 with an attendance of 102. Speakers were Norwood L. Simmons, SMPTE President, who delivered a report on the status of the Society; Edward P. Ancona, Jr., Motion Picture Research Council, who discussed "The Motion Picture Research Council Closed-Circuit Television Film Facilities"; and Arthur Mendola, X-Ray Dept., General Electric Co., who talked about "The General Electric TVX System."

Dr. Simmons briefly described some of the accomplishments of the Society in recent years and outlined the role of the SMPTE in sponsoring the Fifth International Congress on High-Speed Photography, to be held in Washington, D. C., October 16–22, 1960.

Mr. Ancona described the installation and use of a 3-vidicon, color-television closed-circuit film chain which has been installed at the Motion Picture Research Council in Hollywood. This equipment is used to review television films produced by the Research Council member companies, as an instrument of quality control in checking television films, as an instructional device in demonstrating the limitations of television film reproduction, and as a basis for experimental work in electronic techniques. 16mm, 35mm, and slides can be projected and a standard television signal is delivered to home-type receivers. A high quality studio monitor is also available for comparison with the home-receiver image.

Mr. Mendola described the General Electric TVX system which permits the making of X-ray motion pictures through the combining of a television camera sensitive to X-rays and a 16mm kinescope recording camera. The use of this system for heart catheterization and angiocardiography was described and typical kinescope recordings produced on this equipment were shown. The two primary advantages of this system are (1) that the patients exposure to X-rays can be reduced to a fraction of that required for conventional fluoroscopy, and (2) that the resulting film can be carefully and repeatedly examined to obtain information not readily observed by other means.—Ralph E. Lovell, *Secretary-Treasurer*, 2554 Prosser Ave., Los Angeles 64, Calif.

The New York Section met on January 13 at the World Affairs Center Auditorium with an attendance of 38. Guest speaker J. R. Popkin-Clurman, President and Director of Research, Telechrome Manufacturing Corp., discussed the "Status of Television Overseas."

Mr. Popkin-Clurman, recently returned from Geneva, where he was one of the CCIR United States delegates on television and color television, has visited practically all of the countries using television. In his address to the New York Section, he gave a first-hand account of television in the Soviet Union, Europe, England, Australia, Thailand and Japan. His remarks about the political considerations associated with TV engineering problems in Russia were to the point. He stated that they were very interested in our video-tape systems, which they are not using presently. Japan, he pointed out, is vigorously building up her television industry. He added that, while there is a government network, there are many independent stations that are very competitive.

Finally, the speaker showed a collection of color slides of the various countries he had visited. Included in the slides were several shots of Japanese television equipment that showed a high degree of development.—James W. Kaylor, *Secretary-Treasurer*, Movielab Film Labs., Inc., 619 W. 54 St., New York 19, N.Y.

Despite foul weather, a record audience of 71 attended the first 1960 meeting of the **Rochester Section** on January 21 at the Dryden Theatre. Herbert Lavin, General Electric Co., was the guest speaker.

At the beginning of the meeting, two short films—*The Griffith Report* and *The History of the Cinema*—were shown. Following these films, Mr. Lavin presented his paper entitled "Large Screen Television and Electronic Data Projection," which included a description of a General Electric development wherein a light valve is produced by interposing the deformation of a transparent fluid within a schlieren optical system. Deformation is controlled by impingement of an electron beam on a specially designed fluid. The light source of the schlieren system is a xenon lamp.

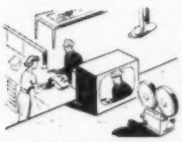
In order to encourage and stimulate attendance at future meetings, those present were advised of the complete agenda for the year. The officers of the Section met prior to the announced evening meeting to discuss plans and programs for the 1960 season.—Wilbur G. Hill, *Secretary-Treasurer*, 10 Hillcrest Ave., Binghamton, N.Y.

The San Francisco Section met on January 12 at Palmer Films Inc., with an attendance of 37. Bill High, Director of Photography, Oakland Junior College, guest speaker, discussed "Basic Optical Terms."

In his talk, Mr. High explained the basic optical terms now in common use and illustrated their applications. Various lens types, their historical backgrounds and optical data, were discussed. A collection of old lenses and shutters were on display for both viewing and discussion. The speaker was associated with the Camera Department of Metro-Goldwyn-Mayer in Hollywood prior to joining the Oakland College Staff.

Coffee and doughnuts were served at the conclusion of the meeting through the courtesy of Palmer Films Inc.—Frank Mansfield, *Secretary-Treasurer*, 57 Stoneyford Ave., San Francisco 24, Calif

"VFR" APPLICATIONS:



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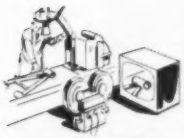
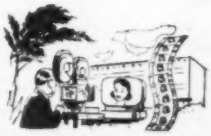


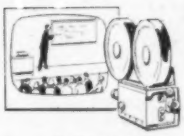
X-RAY INSPECTION



CHECKING TV COMMERCIALS

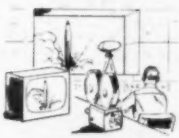
BUSINESS MEETINGS

MEDICAL



EDUCATION

RESEARCH



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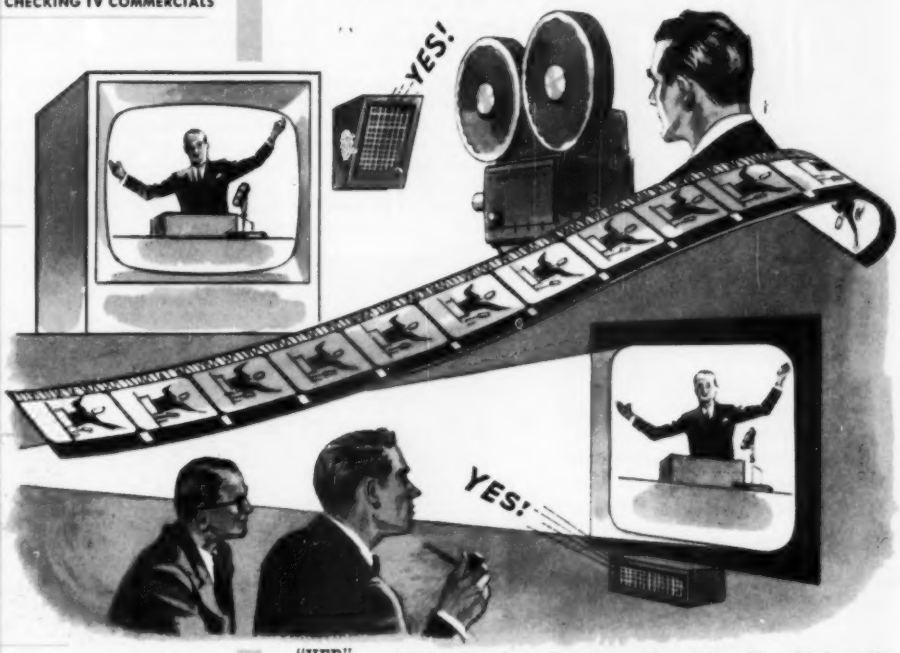

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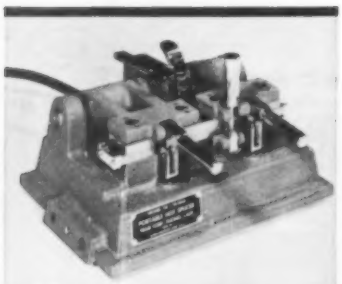

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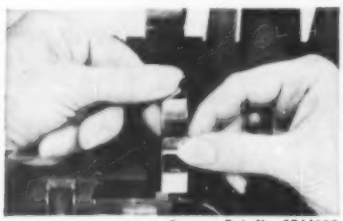

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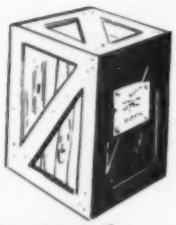


new products

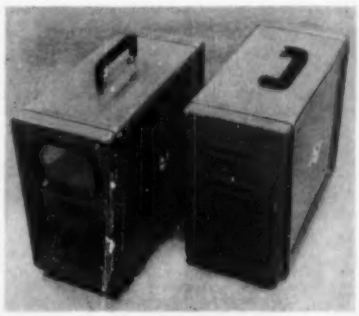
(and developments)

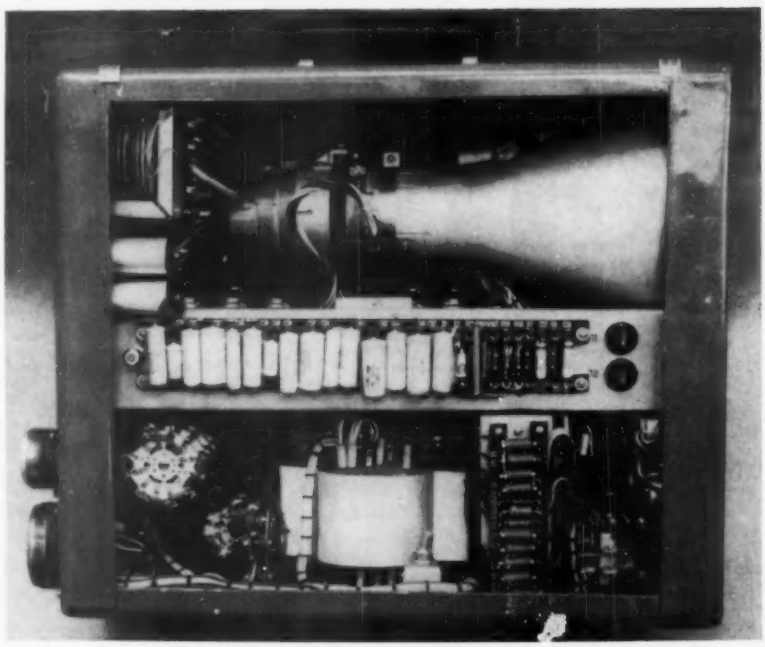
Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products or services.

Underwater television equipment was among equipments shown at the recent U.S.S.R. Exposition of Science and Technology at the New York Coliseum. The image-orthicon camera chain illustrated is comprised of an image-orthicon camera, camera-control/monitor unit and a combination sync generator/sweep generator/-power supply unit.

Long cable runs between camera and control and supply units are achieved by using sinusoidal waveforms for both horizontal and vertical deflection. The resultant elimination of much of the usual pulse forming and timing circuits also permits much more compact packaging as evidenced by the dimensions of the terminal equipment relative to the 7-in. monitor tube.

Surprisingly, one of the most unusual features of this equipment, aside from the use of sinusoidal sweeps, is the physical similarity to American equipment, as can be noted from the side view of the inside of the camera control and monitor unit.—Photos by *Haig Armen Manoogian*, 130 Post Ave., New York 34.





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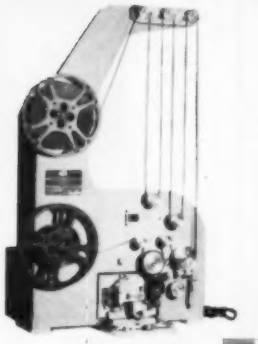
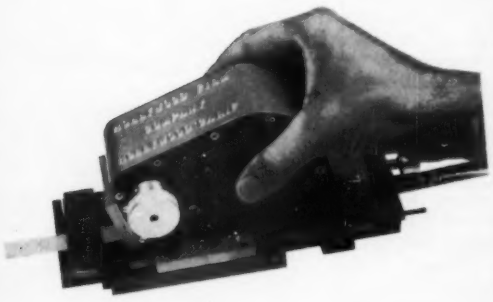
"A new 35mm Angenieux Zoom Kine Lens has been announced by James A. Sinclair & Co., 3 Whitehall, London, S.W.1. Dimension of the lens is 5¼ by 2¼ in. The aperture is *f*/3.5 and focal range from 35mm to 140mm. It is priced at £275."—This announcement was published on p. 77 of the January 1960 *Journal*, except that the price was erroneously given as 275 dollars rather than pounds. The *Journal* regrets the error.

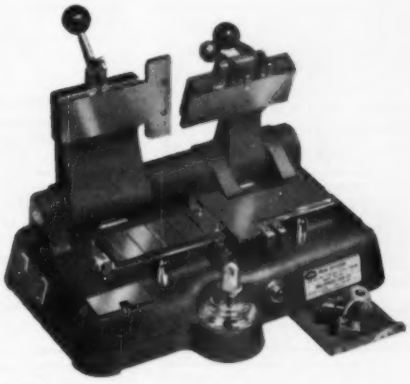


EDGE NUMBERING MACHINES

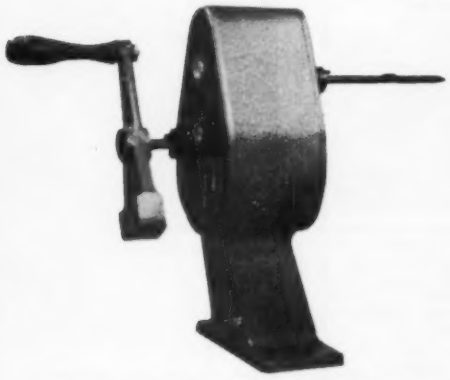
NEGATIVE BREAKDOWN REWIND



AUTOMATIC SPLICERS



HOT SPLICERS



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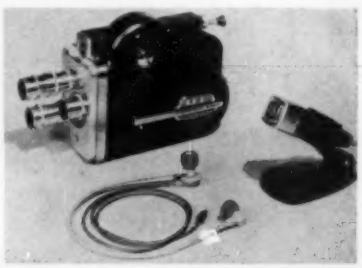
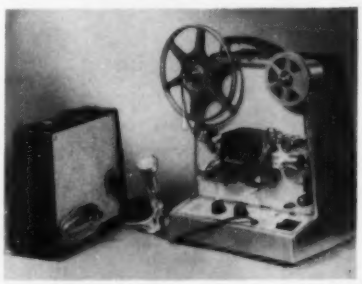
The Zoomatic, an 8mm electric eye camera designed to zoom smoothly from long shots to close-ups and to shift instantly from normal speed to slow motion has been announced by Bell & Howell, 7100 McCormick Rd., Chicago 45. A fast lens (*f*/1.8), called Varamat, based on an 11-element, color corrected optical system, zooms from 9mm to 27mm. A 3-turret model, the 410, similar to the Zoomatic, also features smooth, rapid shifting from normal to slow speed. The 410 has a 10mm *f*/1.8 normal Anastigmat lens, 6.5 wide-angle and 25mm telephoto lenses. The Zoomatic is 5.7 in. high, 7 in. long and 2.34 in. wide and weighs 3 lb. The 410 is 5.7 in. high, 5.3 in. long and 2.34 in. wide. It weighs 2 lb 8 oz. The price for each model is $199.95.



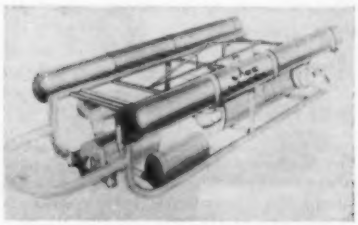


An 8mm camera with a self-contained sound system, called the Fairchild Cinephonic Eight, has been announced by Fairchild Camera and Instrument Corp., Robbins Lane, Syosset, L.I., N.Y., together with a companion projector and 25-mil magnetic stripe color film specially developed for this camera by Ansco. The camera is 7¼ in. long, 3¼ in. wide and 6¼ in. high. It weighs about 4½ lb. The built-in amplifier is completely transistorized with printed circuit. It is priced at $239.50. The projector has a built-in sound amplifier, recording and erase head; separately housed speaker unit and microphone. It weighs 24 lb with a film reel capacity of 400 ft. It is priced at $249.50. The film is color reversal. The speed is equivalent to ASA-12 tungsten and ASA-10 Daylight (with 85-B filter). It is priced at $7.50 for a 50-ft, double 8mm roll.

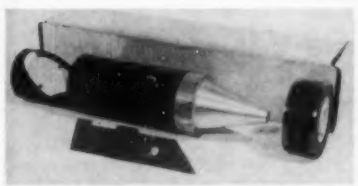
A line of camera parkas — heater covers to keep the camera warm and dry during weather instrumentation tests — has been introduced by Birns & Sawyer Cine Equipment Co., 6424 Santa Monica Blvd., Hollywood 38. Said to keep film pliable in temperatures as low as −60 F, a three-way control switch is used to adjust the heaters for low-, medium- or high-current draw, depending on weather conditions. Insulating materials are kapok and wool, aluminum foil, firm sheet lead, fiber glass and reverse-faced flannel with the flannel side toward the heater element to retain warmth. Canvas backing of the flannel is toward the camera to absorb wear. The outer layer is du Pont Fabrilite. The white outer layer and second layer of aluminum foil also reflect heat and sun when the units are used in hot desert areas. Prices range from $120.00 to $256.00.

A vacuum-driven magnetic tape transport, first unit in the Honeywell 800 data-processing system to be shown, has been announced by the Datamatic Division, Minneapolis-Honeywell Regulator Co., 261 Madison Ave., New York. The all-vacuum drive (clutch) and the use of vacuum to hold the tape reel on its hub and the tape on the reel is designed to minimize wear and tear on the tape and thus greatly increase its life expectancy. The design is for a speed of 120 in./sec in either direction with a rewind speed of 360 in./sec. Reported rate of reading or recording is up to 96,000 decimal digits/sec.

The firm also announced a device called Orthotronic Control which automatically detects and corrects errors in electronic data processing. This device is described as "basically . . . a mathematical technique that permits the system to detect any errors and correct them instantly and automatically." Commercial production on the data-processing systems is expected to begin in October.



A mobile underwater vehicle system (M.U.V.) that can be equipped with a closed-circuit TV camera chain for underwater surveys has been developed by Vare Industries, 128 W. First Ave., Roselle, N. J., in cooperation with the Department of the Navy. Operation is remotely controlled from a console on the mother ship by means of a multiconductor cable. The vehicle is propelled and guided by means of three electric propulsion motors, gear-connected to propellers. The port and starboard units control the lateral motion fore and aft and also control the direction. This propulsion system permits the vehicle to hover at any desired depth in currents or tides of several knots. TV images, and information on depth, propeller speed, etc., are displayed at the console. Suggested applications include oceanographic studies, underwater inspection, location of lost objects, such as sunken ships, treasure hunts and sampling operations.



A projector alignment tool kit developed by the Motion Picture Research Council contains (1) a film path gauge to line up mechanically the fixed guide roller, the guide rails and the narrow-tooth intermittent sprocket; (2) an optical alignment tool to position the carbon arc and the mirror on the optical axis of the projection lens; (3) sufficient footage of 35mm all-purpose projector alignment film to make from two to three loops depending on the type of projector. This film is used in conjunction with the alignment tool to center the image on the film on the optical axis.

The film path gauge is a precision tool to align the fixed guide roller, the guide rails, and the teeth of the intermittent sprocket, and can be inserted in the aperture of any projector having narrow-toothed intermittent sprockets. The optical alignment tool is used to align the illumination

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system with the optical axis of the lens, and is used with the projector alignment film to allow the proper orientation of the projector with the center of the screen. A set of instructions is included with the tool kit. It is priced at $32.50 and is available from the Motion Picture Research Council, Inc., 6660 Santa Monica Blvd., Hollywood 38.

The University of Michigan's English Language Institute has installed a closed-circuit television system adapted to the special requirements of training teachers to teach the English language in foreign countries. The system is based on the Giantview projector, manufactured by Giantview Television Network, Ferndale, Mich., which projects TV images on an 8 ft by 6 ft lenticular screen. The screen is supplied by Radiant Screen Co., Chicago. Lip and tongue movement of language students may be shown on the screen enlarged to 12 times life size. Cameras are supplied by RCA. The installation was planned and supervised by Prof. Garnet R. Garrison, Director of Broadcasting, and Frederick M. Remley, Jr., Technical Director of Radio and TV. This is the fourth closed-circuit system installed by the University of Michigan. It was financed by a grant from the Ford Foundation.

Mecca Film Laboratories, Inc., New York, has been sold to Byron Roudabush, President of Byron Motion Pictures, Inc., Washington, D. C., and has been renamed Mecca Film Laboratory Corporation. Announcement was made by Harry Glickman, founder of the firm, who will continue with the new corporation in an advisory capacity. Mr. Roudabush is President and Treasurer of the new corporation. Vice-Presidents are Jack Haber, Samuel Breitenstein and Dudley Spruill.

Gordon Enterprises of North Hollywood has been appointed exclusive representative in the Western United States for Canadian Applied Research, Ltd., of Toronto, Canada. Products include the Mark VII aerial camera, and the Mark VIII, designed for automatic recording on continuously moving 35mm film, and the Mark III automatic Tri-Film processor and 70mm studio camera.

The Rubylite portable movie light is a product of Photomart, 228 S. Franklin St., Tampa, Fla. The device is designed to fit any camera and can be attached or removed without tools. It runs on a nickel cadmium rechargeable battery. Dimensions are 7 in. by 6½ in. by 3 in. Weight is about 5 lb. It covers a 10mm lens area. The color temperature is 3400 K. It is priced at $169.50.

A magnetic recording tape, called Triton tape, is distributed in the United States by Brand Products, 39 W. 55 St., New York 19. Described as "splice-free," the tape is wound on "nonwarp, nonsqueal" reels and includes heavy-duty du Pont Mylar at both ends for protection and to facilitate labeling. The tape is available in both acetate and du Pont Mylar polyester film in a wide range of reel sizes and types.

Following a decentralization policy, Ampex Corp. has formed five companies to handle various operations and conduct business within the United States. Foreign operations are conducted through Ampex International which controls a group of subsidiaries. The five recently formed domestic companies are Data Products; Professional Products; Military Products; Audio, Inc., which manufactures stereophonic systems and related consumer products; and Orr Industries, manufacturer of magnetic tapes. Orr was acquired by Ampex by a recent merger.

The Society of Plastics Engineers held its 16th Annual Technical Conference Jan. 12–15, in Chicago. The theme of the Conference was "Professional Achievements and Approaching Opportunities in the Growth of Plastics Engineering." More than 80 papers were presented in 23 sessions covering many aspects of plastics engineering. Among the session topics were Polymer Structure; Plastics in Buildings; Reinforced Plastics; Mold Design; Forming; Foams; Thermosetting Molding; New Materials; Radiation and Missiles, and Rheology.

A new 13-story office building located at 1725 K St. N. W., Washington, D.C., has been named the RCA Building. Owned by Paramount Building, Inc., the building has been partially leased for $2½ million by Radio Corp. of America which will occupy half of the street floor and the second, third and fourth floors. Most of RCA's Washington, D.C., operations will be centralized in this building.

Announcement of a new TV tape center to be established in Los Angeles has been made by the Radio Corp. of America. The center will provide services ranging from engineering assistance to application planning and supplying components for the RCA TV tape recorder.

A brochure giving a complete description of the Perkin-Elmer lightweight aerial panoramic camera (*Jour.* p. 59, Jan. 1959) has been published by the Electro-Optical Division, Perkin-Elmer Corp., Norwalk, Conn. The 8-page brochure contains a number of illustrations and diagrams and describes the operation and specifications of the camera. The camera employs rapid scanning principles to obtain successive horizon-to-horizon photographs covering 180° across a plane's line of flight.

Preliminary steps toward a merger of Consolidated Electrodynamics Corp. and Bell & Howell Co. have been taken and the merger has been approved in principle by the directors of both companies. CEC, a supplier of aviation and missile test equipment, electronic instrumentation and control systems, magnetic tape equipment for instrumentation and data processing, and vacuum systems and controls. The

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company employs about 3000 people. Bell & Howell employs about 4000 people. If the merger goes through, directors of both companies have agreed in principle on a distribution of three additional Bell & Howell common shares for each four shares presently held, and CEC shareowners would receive one share of Bell & Howell common stock in exchange for each share of CEC.

Federal Manufacturing and Engineering Corp., 1055 Stewart Ave., Garden City, N.Y., has announced acquisition of two firms, Television Specialty Co., manufacturers of motion-picture and television broadcasting equipment, and Cameraflex Corp., manufacturers of motion-picture cameras for missile tracking and instrumentation work. Federal's plan is to combine the two companies with its present enlarger and micro-film departments to form a photo products division. K. A. Jenkins, President of Television Specialty Co., will head the newly formed group. Plans included development of medical, military and industrial photographic equipment.

The Hallen Electronics Co., manufacturer of magnetic film recording equipment, has moved to larger quarters, at 652 S. Myers St., Los Angeles 23. The two-story building covers 30,000 sq ft with electronic, mechanical and manufacturing operations occupying the second floor, and administrative, sales and accounting on the ground floor.

A new RCA plant for the manufacturing of industrial electronic products will be constructed in Pennsylvania in the Washington-Canonsburg area. Plans call for immediate construction of an administrative and engineering building covering 50,000 sq ft on a 50-acre site, with provision made for possible future expansion requiring a manufacturing center covering 130,000 sq ft.

These notices are published for the service of the membership and the field. They are inserted three months, at no charge to the member. The Society's address cannot be used for replies.

Film Writer-Director-Editor with broad administrative, advertising and public relations background. Fully capable of supervising industrial audio-visual department. Screen credits include all types of films from documentary to drama. Know cost control, sound recording, evaluation, equipment. Write Film Director, 4410 Walsh St., Chevy Chase 15, Maryland.

Industrial Photographer, Producer, Director desires position with vigorous film production outfit in either production or organization. Will accept heavy project responsibility. Experienced in all phases of motion-picture production and laboratory operations. Thoroughly familiar with military photographic requirements especially in the area of missile R & D. Single, willing to relocate. Resume on request. Write: Avrum M. Fine, 272 West 17th St., Hialeah, Fla.

Cameraman Trainee. Young Nigerian wishes to be trained as TV or motion-picture cameraman. Six years local training in Nigeria as projectionist-technician plus 2 yrs work and study in same field with C.M.A. Ltd., London. Practical experience in operation and maintenance of 16 & 35mm films and projectors. Serious student of film since age 15—now 24. Currently employed but anxious to train for a position where ability, sincere interest and creativeness offer opportunity. Will locate anywhere in U.S. Top industry and character references supplied in confidence. Sunny De Iseghohimen, Ministry of Research & Information, Film Production Unit, Ikoyi-Lagos, Nigeria.

Motion-Picture Technician. Just returned from 2 yrs work in Europe and Asia, including installation of motion-picture laboratory in Pakistan for Reevesound, Inc., and production management for Alfred Wagg Pictures. Formerly with Capital Film Laboratories, Washington, D.C., for several yrs; also designed and built production and lab equipment since 1945 under company name of Telex Films. Experienced to do capable work in production, editing, sound and laboratory. Particularly interested in overseas positions, will consider any part of the world. Complete resume on request. Victor E. Patterson, c/o Frank Enge, Jr., 1025 Connecticut Ave., N.W., Washington, D.C.

Positions Available

Photographic Instrumentation. Los Angeles area firm manufacturing photographic instrumentation equipment needs a sales engineer. Engineering degree preferred. Position consists of selling, training field personnel, field service, and relating customers' requirements to the design of new products. Send resume to P.O. Box 22140, Los Angeles 22, Calif.

Laboratory Processing. Experienced or inexperienced processing man wanted by 16mm lab in Chicago area offering negative, positive, reversal and soundtrack developing. Write P.O. Box 401, West Chicago, Ill.

Motion-Picture Production. Organizers of new corporation in Managua, Nicaragua, require man well versed in professional motion-picture photography, with working knowledge sound recording, color, laboratory work, etc., to prepare budget of equipment necessary to start operating a motion-picture studio on an economical basis. Applicants should preferably be in a position to go to Managua to assist in the installation and operation of the studio, and in the selection and training of technical personnel. Send full information and salary requirements to: Conrad Morgan B., P.O. Box 1926, Managua, Nicaragua.

Cameraman. Prefer man with considerable experience on Mitchell Cameras. Midwest producer with fine reputation and financial standing wants man with ability and experience in lighting sets and operating camera on all kinds of interior and exterior photographic assignments. Very little travel involved in job. Excellent starting salary and opportunity. Write giving full details of past and present employment, equipment used, positions held, etc. Technisonic Studios, Inc., 1201 Brentwood Blvd., St. Louis 17, Mo.

Sales Engineer. Opportunity with West Coast office for sales engineer with manufacturer of theatre lighting and control equipment and architectural incandescent lighting. Work requires ability to call on architects, theatres, consulting electrical engineers, contractors. Location: in and around Los Angeles area. Please forward complete information, which will be kept in strict confidence, to: Century Lighting, Inc., 1840 Berkeley St., Santa Monica, Calif.

Photographer-Editor. Studio in Dallas, Texas, requires qualified motion-picture photographer and editor. Prefer college training. Please furnish references along with resume and salary requirements to: Keitz & Herndon, 3601 Oak Grove, Dallas 4, Texas.

Photographic Equipment Engineer. Excellent opportunity for photo engineer with thorough experience in determining special equipment needs for large photo lab operations, and executing the design specifications thereof. Will act as the authority on systems modifications and additions. Should have knowledge of printing equipment, processing and sensitometry. Write W. F. Marquette, RCA Service Co., Mail Unit 114, Patrick Air Force Base, Florida.

Instrument Design Engineer. To assist with the design of high-speed motion-picture cameras and related products. Degree required in mechanical or electrical engineering with four yrs minimum design experience. A challenging position with a growing company. Write: T. H. Truesdell, D. B. Milliken Co., 131 N. Fifth Ave., Arcadia, Calif.

Television Engineer. GS-855-12, $8810 per yr. To plan, design, coordinate, test and evaluate television equipment for military applications. Position will require about 50% traveling within and possibly outside continental limits of U.S. Applicants must have either 4-yr academic engineering training with bachelor's degree, or equivalent experience or combination of college training and experience; in the latter cases a written test will be required. *Also,* **Sound Recording Equipment Operator Foreman** for TV Division, $4.09 per hr; **TV Video Equipment Operator Foreman** for Television Division, $4.25 per hr. For all positions, Standard Form 57 (Application for Federal Employment), obtainable from the U.S. Civil Service Commission or any Post Office, should be completed and sent to: Civilian Personnel Office, Army Pictorial Center, 35-11 35th Ave., Long Island City 1, N.Y. RA 6-2000, Ext. 238.

Equipment Technicians. To maintain, service, repair all types of mechanical and electronic production equipment. Excellent salary and opportunity to advance with expanding organization. Write fully, all letters kept in strict confidence: Arthur Florman, Florman & Babb, Inc., 68 West 45 St., New York 36.

Equipment Salesmen. To call on industry, government, film producers. Must be willing to travel. Excellent salary and opportunity to advance with expanding organization. Write fully, all letters kept in strict confidence: Arthur Florman, Florman & Babb, Inc., 68 West 45 St., New York 36.

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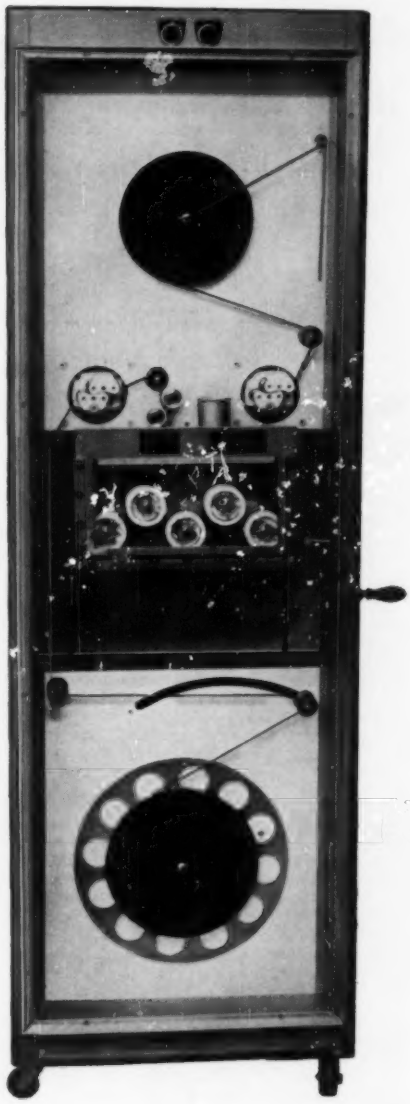

All you have to do is put the film in place and fill the solvent tank. The new Unicorn cleaner does the rest automatically—and speedily with all scrubbing action taking place below the solvent level. It effectively cleans motion picture films (negative and positive) and magnetic tape at rates to 300 feet per minute with complete safety. Cleaning is accomplished by counter-rotating velvet covered scrubbing rollers, effectively removing dirt, lint, oil, fingerprints and wax.

The Model A-5100 is a combination 16/35 mm film cleaner. Other cleaners are available for 16 mm film only, 35 mm film only and for 70 mm film only. All models include these special features:

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Meeting Calendar

Deutsche Kinotechnische Gesellschaft, Annual Meeting and Equipment Exhibit, Mar. 1–5, 1960, Technical University, Berlin.
National Electrical Industries Show, Mar. 6–9, 1960, Coliseum, New York.
ASCE, New Orleans Convention, Mar. 7–11, 1960, Jung Hotel, New Orleans, La.
IRE National Convention, Mar. 21–24, 1960, Coliseum and Waldorf-Astoria Hotel, New York.
American Chemical Society, National Meeting, Apr. 5–14, 1960, Cleveland, Ohio.
Optical Society of America, Spring Meeting, Apr. 7–9, 1960, Hotel Statler, Washington, D.C.
Inter-Society Color Council, 29th Annual Meeting, Apr. 11, 12, 1960, Philadelphia Museum College of Art, Philadelphia.
Microwave Research Institute of Brooklyn Polytechnic Institute, Tenth International Symposium on Active Networks and Feedback Systems, Apr. 19–21, Engineering Societies Bldg., 33 West 39th St., New York
IRE, South West Regional Conference and Electronics Show, Apr. 20–22, 1960, Shamrock-Hilton Hotel, Houston, Texas.
Manned Space Stations Symposium, Apr. 20–22, 1960, Ambassador Hotel, Los Angeles.
87th Semiannual Convention of the SMPTE, including Equipment Exhibit, May 1–7, 1960, Ambassador Hotel, Los Angeles.
IRE National Aeronautical Electronics Conference, May 2–4, 1960, Dayton, Ohio.
American Rocket Society, May 9–12, 1960, Ambassador Hotel, Los Angeles.
Society of Photographic Scientists and Engineers Annual Conference and Equipment Exhibit, May 9–13, 1960, Hotel Miramar, Santa Monica, Calif.
Society of Military Engineers, National Convention, May 16, 17, 1960, Washington, D.C.
ASME, Design Engineering Div. Conference, May 23, 1960, New York.
Design Engineering Show, May 23–26, 1960, Coliseum, New York.
Institute of the Aeronautical Sciences, National Summer Meeting, Mid-June, 1960, Los Angeles.
Acoustical Society of America, Spring Meeting, June 9–11, 1960, Providence, R.I.
National Society of Professional Engineers, Annual Meeting, June 9–11, 1960, Statler Hotel, Boston, Mass.
International Electronic, Nuclear and Cinematographic Exhibition, June 15–July 5, 1960, Rome, Italy.
AIEE, Summer General Meeting, June 19–24, 1960, Atlantic City, N.J.
American Society for Engineering Education, Annual Meeting, June 20–24, 1960, Purdue Univ., West Lafayette, Ind.
First Congress International Federation of Automatic Control, June 25–July 9, 1960, Moscow, U.S.S.R.
American Society for Testing Materials, Annual Meeting and Apparatus Exhibit, June 26–July 1, 1960, Chalfonte-Haddon Hall, Atlantic City, N.J.
AIEE, Pacific General Meeting, Aug. 8–12, 1960, San Diego, Calif.
European Conference on Electron Microscopy, Aug. 29–Sept. 3, 1960, Delft, Netherlands.
AIEE Fall General Meeting, Oct. 9–14, Chicago.
NEC National Electronics Conference, Oct. 10–12, 1960, Hotel Sherman, Chicago.
Fifth International High-Speed Congress and Equipment Exhibit, sponsored by the SMPTE, Oct. 16–22, 1960, Sheraton-Park Hotel, Washington, D.C.
Symposium on Space Navigation, Oct. 19–21, 1960, Columbus, Ohio.
89th Semiannual Convention of the SMPTE, May 7–12, 1961, King Edward Sheraton, Toronto.
90th Semiannual Convention of the SMPTE, Oct. 2–6, 1961, Lake Placid, N.Y.
91st Semiannual Convention of the SMPTE, Apr. 30-May 4, 1962, Ambassador Hotel, Los Angeles.
92nd Semiannual Convention of the SMPTE, Oct. 22–26, 1962, Drake Hotel, Chicago.

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections, Subsections and Chapters, and of the Committee Chairmen and Members were published in the April 1959 Journal.

sustaining members

of the Society of Motion Picture and Television Engineers

The objectives of the Society are:

- Advance in the theory and practice of engineering in motion pictures, television and the allied arts and sciences;
- Standardization of equipment and practices employed therein;
- Maintenance of high professional standing among its members;
- Guidance of students and the attainment of high standards of education;
- Dissemination of scientific knowledge by publication.

Progress toward the attainment of these objectives is greatly aided by the financial support provided by the member companies listed below.

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  Twentieth Century-Fox Film Corp.
  United Artists Corporation
  Universal Pictures Company, Inc.
  Warner Bros. Pictures, Inc.
Motion Picture Enterprises, Inc.
Motion Picture Laboratories, Inc.
Motion Picture Printing Equipment Co.
Movielab Film Laboratories, Inc.
Moviola Manufacturing Co.
National Carbon Company, A Division of Union Carbide and Carbon Corporation
National Screen Service Corporation
National Theatre Supply Company
Neumade Products Corporation
Northwest Sound Service, Inc.
Panavision Incorporated
Pathé Laboratories, Inc.
Pittsburgh Motion Picture Laboratory
Warren Conrad Portman Company
Precision Laboratories
  (Division of Precision Cine Equipment Corporation)
Prestoseal Mfg. Corp.
Producers Service Co.
Radio Corporation of America
  National Broadcasting Company
  Broadcast and Television Equipment Division.
Rank Precision Industries Ltd.
Rapid Film Technique, Inc.
Reid H. Ray Film Industries, Inc.
Reeves Sound Studios, Inc.
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Wilding Inc.
Wollensak Optical Company

The Society invites applications for Sustaining Membership from other interested companies. Information may be obtained from the Chairman of the Sustaining Membership Committee, Byron Roudabush, c/o Byron Motion Pictures, Inc., 1226 Wisconsin Ave., N.W., Washington 7, D.C.